A GUIDEBOOK FOR LOCAL GOVERNMENTS FOR DEVELOPING REGIONAL WATERSHED PROTECTION PLANS

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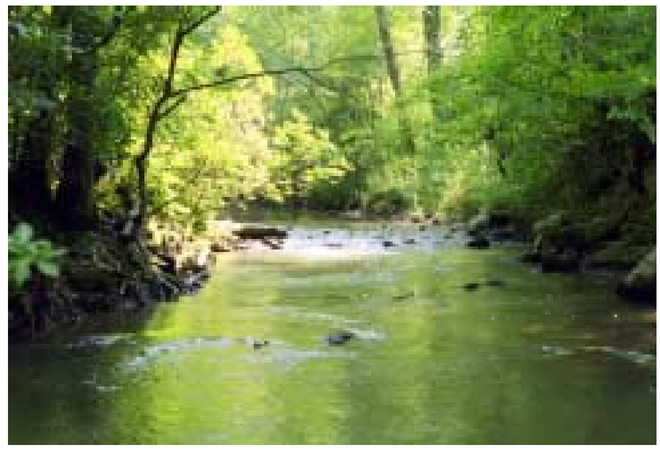
Prepared for
Georgia Environmental Protection Division
Water Resources Branch
Water Resources Management Program

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The management of Georgia's waterways continues to become increasingly complicated as new regulations are developed and existing regulations are more strictly enforced in an effort to improve water quality. Regulation of water pollution has, in the past, focused primarily on point sources such as factories and municipal wastewater treatment plants that discharge process or wastewater to streams and rives. Regulation of point sources has traditionally been implemented in such a manner as to isolate each source rather than considering the cumulative effect of multiple sources, including nonpoint sources, on downstream waterbodies. In addition, the various regulatory programs were themselves developed and enforced in isolation from each other. There is a current movement towards integration of watershed regulations with a stronger focus on nonpoint source pollution. The goal of this movement is to have more effective pollution control while streamlining the compliance process for all involved.



A common denominator to many land management and water supply/water quality protection mandates is a requirement for the development of watershed protection plans. A well-conceived plan will achieve multiple goals for local governments, including source water protection, stormwater management, greenspace planning, wastewater management, erosion and sediment control, and long-term protection and sustainability of water quality and quality of life for citizens. Such plans must be broad-reaching across political jurisdictions and be inclusive of public and private stakeholders to be acceptable and achievable.

Document Objectives

This document is intended to assist local governments in developing regional watershed protection plans to meet multiple regulatory requirements. The Georgia Environmental Protection Division (EPD) encourages local governments and government owned community water system owners to prepare comprehensive watershed protection plans that can address all elements of EPD's various watershed assessment and protection programs. EPD also encourages a regional approach to define and address water quality problems, since watershed do not follow political jurisdictional boundaries.

The Alcovy River Watershed Protection Project is used as an example throughout this guidebook and is presented as a case study in Appendix A to exemplify the steps required to conduct watershed assessments and prepare watershed protection plans. While each of Georgia's watersheds has circumstances and issues unique to its physiographic, land use, political and demographic

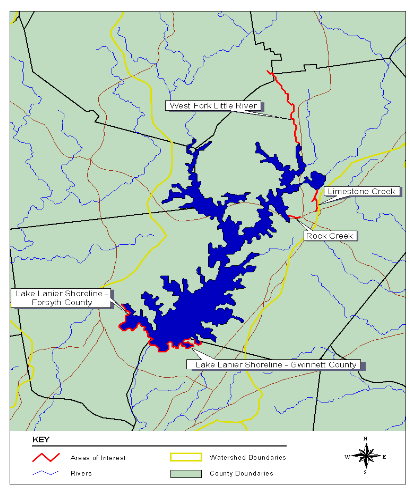
characteristics, the Alcovy project can be used as a model for local governments to develop a regional cooperative approach to watershed protection.

There are several additional resources that can assist local governments in watershed planning and protection. The Center for Watershed Protection provides technical information to local, state, and federal governmental agencies, environmental consulting firms, watershed organizations, and the general public on urban watershed protection and restoration (http://www.cwp.org). The Carl Vinson Institute of Government (CVIOG) at the University of Georgia provides assistance to local governments through training, education, and scientific and policy research (http://www.cviog.uga.edu). A separate guidebook is available from CVIOG that focuses specifically on protection of water supply watersheds (Kundell and DeMeo, 2000). A second publication from CVIOG discusses regional water management alternatives for Georgia (Kundell and DeMeo, 1999). These resources are useful supplements to this guidebook and present concepts and tools for watershed protection similar to those discussed in the following sections.

MEETING REGULATORY REQUIREMENTS

A summary of key regulatory drivers likely to affect local governments throughout Georgia is outlined below. Some regulations are specific to water supply watersheds while others apply to any and all watersheds.

The Georgia Planning Act



Local governments in Georgia must meet the environmental protection standards of the Georgia Planning Act. This law requires that each local government adopt a comprehensive land ue plan that includes a natural resource element and subsequent regulations. The Georgia Department of Community Affairs (DCA) establishes minimum standards and procedures and is responsible for reviewing and approving plans. These plans and regulations must include minimum criteria established by Georgia's Department of Natural Resources, including the criteria for water supply watersheds and river corridor protection. Together these are commonly known as the "Part V Criteria." The most stringent of these requirements are those for small water supply watersheds. If the drainage area above a drinking water intake is smaller than 100 square miles, the watershed is considered a small water supply watershed. Streams within 7 miles upstream of the intake must be protected by riparian buffers of 100 feet, with a 150 foot (total) setback for structures. Streams above 7 miles are protected by 50 feet buffers, with a 100-foot structure setback. Furthermore,

impervious surfaces cannot cover more than 25% of the total area of a small water supply watershed.

If the local governments choose, they may petition the EPD and DCA to allow an alternative approach to watershed management, in lieu of meeting the standard requirements. The combination of tools presented in the Alcovy Plan, including a comprehensive stormwater ordinance and a universal 75 ft buffer ordinance, were recommended to provide protection that exceeds that of the standard requirements. The recommendations contained within the Plan will achieve a higher level of water quality protection than the minimum buffer requirements and impervious surface limits of the Part V criteria.

The Rules for Environmental Planning Criteria establishes criteria for the protection of large river corridors. The criteria apply to any perennial river or other waterbody downstream of the point in which the average annual flow is at lease 400 cubic feet per second (cfs), as determined by U.S. Geological Survey documents. The criteria also require protection a 100 foot buffer on both sides of the river, as measured horizontally from the riverbanks.

The Safe Drinking Water Act

The goal of the Safe Drinking Water Act is the development and implementation of prevention and protection strategies to address potential threats to the water supply system identified through the assessment process. This law represents a movement towards a more preventive approach of avoiding contamination of public water supply systems.

The Safe Drinking Water Act regulates public water systems. It requires source water assessments for water supply watersheds above public drinking water intakes.

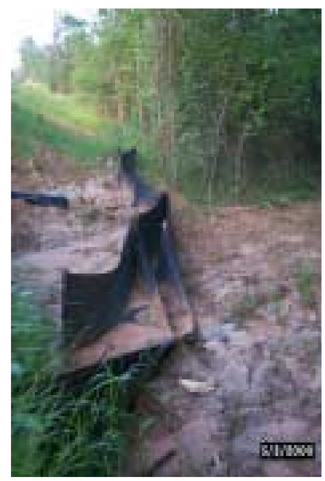
Each assessment must include a delineation of the watershed and source water assessment areas that drain to the intake location, an inventory of potential pollution and contaminant sources, and a determination of the susceptibility of the drinking water source to contamination. The susceptibility analysis is based on the potential for contaminant to be released into the environment, as well as the risk the contaminant poses to the surface water intake should it be released. In addition, the results of the assessment must be made available to the population served by the public water system. This information may then be used for developing source water protection plans as part of local comprehensive planning efforts.

The Clean Water Act

The Clean Water Act prohibits the discharge of any pollutant to waters of the United States from a point source unless the discharge is authorized under the National Pollutant Discharge Elimination System (NPDES) permit. The responsibility for issuing permits in Georgia has been delegated to the EPD through the Georgia Water Quality Control Act.

The EPD has recently begun requiring p applicants to perform watershed assessm order to address water quality issues witl service area of the permitted discharge. assessments include data collection, sam modeling and development of a watershe plan.

Watershed assessments and protection plans are required for reissuance of permits of publicly owned facilities that provide wastewater treatment for flows greater than 1.0 million gallons per day and for those with new or expanding permits. The watershed assessment area includes all streams and other water bodies in the current and proposed service area of the water reclamation facility. This relatively new requirement has been promulgated into law and is the policy of the EPD prior to issuance of new NPDES permits, or expansion of existing permits. This requirement is triggered upon permit renewal or request for capacity expansion.



The Environmental Protection Agency (EPA) has promulgated additional rulemaking that requires NPDES permits for storm water dischargers. While the first phase of this program included only very large municipalities, the second phase applies to smaller municipalities with less than 100,000 people that are located within urbanized areas. Although no jurisdictions in the Alcovy basin were automatically included, the proposed regulation also gives the state agency the authority to include other areas that may be applicable. Requirements of the Phase II permit program include filing a notice of intent (NOI) for permit coverage and developing and implementing a stormwater pollution prevention plan (SWPPP or SWP3). Elements of the plan include:

- Formation of a pollution prevention team
- Identification of stormwater drainage structures and potential pollution sources
- Implementation of stormwater management controls and other best management practices (BMPs)
- Visual and analytical monitoring

EPA has granted authority to Georgia EPD to issue general NPDES permits. EPD has issued a general permit for stormwater discharges associated with construction activities on sites greater than 5 acres, or tracts of less than 5 acres that are part of an overall larger development. Components of the permit include:

- Notification of the facility's intent to comply with the permit
- Preparation of an Erosion, Sedimentation and Pollution Control Plan
- Preparation of a Comprehensive Monitoring Program
- Plan and program implementation

Other revisions to the NPDES Program include EPA's regulatory requirements for establishing Total Maximum Daily Loads (TMDLs). States are required to list waterbodies that are not supporting their designated uses because of failure to meet water quality standards. TMDLs will be established for such waterbodies. A TMDL is the maximum daily amount of a given pollutant that may be discharged to a given waterbody without exceeding water quality standards. TMDLs are based on identifying pollution sources and implementing the necessary control mechanisms to reduce in both point and nonpoint source loadings of target pollutants. In addition, States are required to develop comprehensive lists of all waterbodies that do not attain or maintain water quality standards. States are required to develop their lists every 2 years and will schedule the establishment of all necessary TMDLs. Components of a TMDL include:

- Waterbody name and location
- Identification of the pollutant and the water quality standard for the waterbody
- Amount of pollutant allowable to meet standards
- Load reduction needed to meet standards
- Sources of pollutant (s)
- Waste load allocation for point sources
- Waste load allocation for runoff and other nonpoint sources of pollution
- A margin of safety; consideration of seasonal variation; and allowance for reasonably foreseeable increases in pollutant loads
- An implementation plan

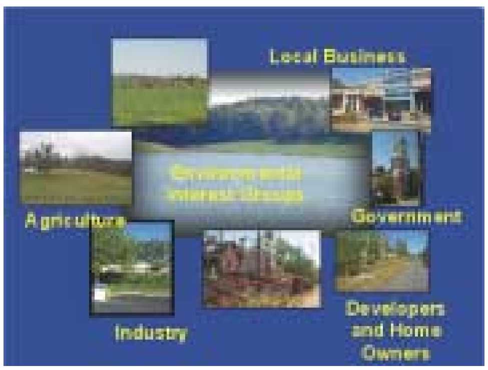
DEVELOPING A COOPERATIVE APPROACH

Rivers and watersheds typically do not conform to political boundaries. The key to successful long-term regional watershed planning and protection is to develop a cooperative approach for identifying problems and implementing solutions across multiple jurisdictions. The steps to creating a cooperative atmosphere can be difficult but are achievable if the following can be accomplished.

The first step to developing a cooperative approach is to identify key representatives from each city and county jurisdiction within the watershed to discuss issues and explore opportunities for regional cooperation for long-term water quality protection.

Bringing People Together

It is important to identify key representatives from all areas of the watershed to come together to initiate a dialogue for regional cooperation. Representatives could include, but are not limited to, local elected officials, city/county managers, and water utility/authority directors, city/county planning, among others. The next step is to bring key stakeholders together. This is best accomplished in a neutral forum with the help of an appropriate facilitator from the local Regional Development Center. Some managers may choose to have a consultant to manage the stakeholder involvement process.



The initial meeting should provide the opportunity for each jurisdiction to voice their particular concerns and issues for meeting requirements related to water supply and water quality protection. Short and long-term goals for meeting these requirements should be identified. It is then the facilitator's responsibility to help find common ground on which all can agree to work together to achieve common goals through a streamlined cooperative process. The outcome of the initial meeting may be simply to agree to meet again to continue the discussion of issues. If the group reaches consensus for future direction, such as exploring the idea of conducting a regional watershed study or developing a watershed management plan, then the next step is to begin crafting a mission statement for each participating government. Considerations for framing the mission statement and charting a general course of action include:

- Defining the general nature of the project (s)
- Identification and coordination with relevant existing programs and projects
- Assigning roles for elected and regulatory officials
- Defining the nature and extent of public and private stakeholder involvement
- Forming a planning committee to identify needs and potential resources

Identifying Obstacles to Regional Cooperation

As no two watersheds are alike (physically, politically or culturally), neither will the approach be to regional cooperation for a particular area. Some potential obstacles to reaching an agreement for continued regional cooperation for identifying and implementing watershed protection measures are presented below:

There will likely be obstacles throughout the process. However, a clear recognition and understanding of these obstacles early on can help to prevent them from becoming barriers to moving forward.

- Competition for funding regional activities over local issues
- Meshing of individual efforts with regional efforts
- Competition between entities and disputes over other matters that influence the ability to cooperate on a particular issue
- The fear that citizens, developers and businesses will be limited in some way or burdened by additional regulatory requirements
- Short and long-term funding mechanisms for watershed assessment and implementation of watershed protection measures

Developing a Plan of Action

A plan of action is needed at the start to initiate the steps required to meet short-term goals and to ensure long-term regional cooperation. The plan could be loosely developed by the larger regional group, or may be more formally constructed through a planning committee, that is a subset of the larger group. Steps for developing such a plan could include, but are not limited to the following:

- Scheduling initial planning meeting(s)
- Identifying technical activities (such as project needs) and political processes (such as presentations to local commissions)
- Developing a rough scope of work for the project(s)
- Developing a budget and cost allocation method
- Seeking opportunities for partnering with existing programs/projects
- Identification of working or technical advisory committees
- Developing a project schedule, including task and project completion dates and meeting schedules

Once the plan is agreed upon by all participating jurisdictions, a Memorandum of Understanding (MOU) or other contractual agreement should be written and signed by all parties.

Identifying Resources

There may be a variety of existing resources that can be utilized to gather information and for technical expertise. These may include the local Extension Service, the Natural Resources Conservation Service, the Soil and Water Conservation Service, a nearby college or university, among others. Some local governments may have the personnel and expertise in-house to address watershed issues. Others may seek outside consulting services for particular tasks or projects, such as management of stakeholder involvement.

DEVELOPING SHORT AND LONG-TERM GOALS

Identifying goals at the beginning of the project is important to maintaining a vision for long-term water quality and watershed protection.

Goals may vary between jurisdictions and across the watershed. For example, four drinking water intakes are located within the Alcovy River Watershed. Therefore, protection of water supplies was a goal for jurisdictions within these water supply watersheds. For those areas closer to Jackson Lake, protection of the lake from potential upstream threats such as sedimentation, nutrient enrichment, and water withdrawals was a larger concern.

Other examples of long-term goals for watershed planning and protection include:

- Protect water quality throughout the watershed
- Develop and implement an economical, basin-wide approach for water quality protection with flexibility for individual jurisdictions
- Provide local governments with tools to facilitate the decision-making process on planning and management issues related to water quality
- Clearly define implementable strategies that meet or exceed local, state and federal requirements for long-term watershed protection, including:
  - Source Water Assessment Plans (SWAPs) for protection of water supplies throughout the basin
  - Watershed Assessments for future wastewater discharges
  - Environmental Planning Criteria
  - Effective measures for Erosion and Sedimentation Control (E&SC)
  - Improved Stormwater Management
  - Implementation of TMDLs
  - Phase II stormwater requirements for NPDES permits
- Provide a working water quality model and long-term monitoring plan
- Foster informed public opinion about the challenges and opportunities for water quality protection
- Involve the public in watershed protection planning and implementation
- Work with existing organizations and programs to create the foundation for an ongoing program of watershed protection.

PUBLIC PARTICIPATION PROCESS

Public outreach, education and participation is a required component of watershed assessment, planning and implementation. The objectives of the process are to reach out to residents and key stakeholders throughout the study through public meetings, community meetings and one-on-one contact. Effective communication can increase knowledge among local residents about watershed protection efforts and help them understand how they can be involved. It provides the opportunity for input on proposed policy tools and implementation options, and presents opportunities for on-going partnerships between community groups in the assessment area and participating government agencies and utilities.

The overall goal of public involvement is to involve elected and local officials, educate local residents about water quality, and to provide opportunities for meaningful input from the public in developing recommendations for watershed protection planning.

Citizen involvement is critical to the successful implementation of recommended watershed protection policies and practices. Water resource management is a joint venture, requiring a commitment from all sectors of the community: businesses, land owners, citizens, agricultural interests, developers, community leaders and elected officials. Each sector influences land use and land management decisions, which in turn affects water resources. Therefore, individual citizens must first understand their role in helping protect water quality and then take ownership in identifying and solving problems (or preventing foreseeable ones) in order to affect change.

Forming Advisory Committees

Advisory committees can take several forms, including:

Advisory committees provide the opportunity for local jurisdictions, technical experts, and other stakeholders to be involved in the assessment, planning, and implementation process on a continuous basis.

- *Policy Committees* – composed of local elected and appointed officials whose primary objective is to provide direction to the project from a policy perspective
- *Technical Advisory Committees* – composed of representatives from local jurisdictions, including (but not limited to) water utility personnel, city/county managers, etc., as well as other technical experts such as extension agents, university researchers, and other local experts. The objective of such committees is to provide direction and guidance on the technical details of the project

- *Stakeholder Committees* – composed of special interest groups such as watershed associations, environmental organizations, civic groups, homebuilders associations, and local business interests whose objective is to provide a forum for discussion of issues from a diverse cross-section of the community

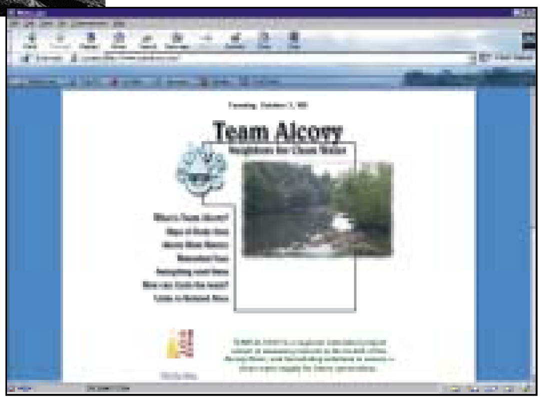
A third party facilitator can be valuable for coordinating meetings and committee activities.

Developing a Public Outreach and Communication Plan

Public outreach should be tailored to the needs of each community based on the issues specific to its leaders and citizens. By targeting outreach to key opinion leaders, successful communication can be accomplished in an efficient and cost-effective manner. Initial meetings with advisory committees can provide the opportunity to discuss the goals and objectives concerning public education and involvement. This process will facilitate the development of a Public Involvement Plan that effectively addresses the vision of the participating local jurisdictions and stakeholders for long-term watershed protection. The plan should be organized to coordinate activities around key milestones of the project. Having such a structure can also help to keep tasks on schedule with the proposed project timeline.

Developing Educational Materials

Materials such as newsletters, fact sheets, educational pamphlets, overlay maps, and display boards for meetings and events are effective means of disseminating information about watershed planning and management at various meetings and events. For exposure to an even larger audience, creating a web site can keep stakeholders informed of project developments, educate them on related issues, and promote general interest in the project. A web site is a cost-effective alternative to a newsletter. Press releases in local newspapers are another way to reach the local community.



Building Partnerships for Solutions

Effectively reaching stakeholders and other concerned citizens is valuable for identifying common concerns and goals and for establishing plans to work together to achieve these goals. This process instills a sense of ownership in citizens and stakeholders alike. Mechanisms for public outreach include stakeholder interviews, public meetings, community presentations, representation at local events, and local demonstration projects. Working with established organizations, associations and other groups provides the opportunity to form alliances to link resources and create innovative ideas.

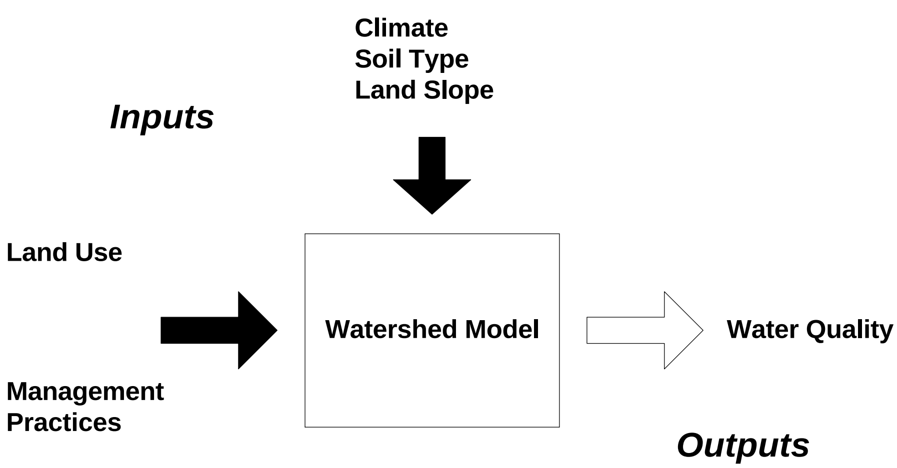
MATHEMATICAL MODELING TOOLS

Overview of Watershed Modeling

Watershed models are used in water resources planning to simulate pollutants coming off the land and the effect that various land uses and other factors may have on water quality in rivers and lakes.

A model is a mathematical description of real world processes. Watershed models can be used to determine the importance of various pollutant sources not only under current conditions, but also under future scenarios. Consequences of future land use management scenarios may be predicted by simulating the generation and movement of pollutants (e.g., sediment, nutrients, bacteria) from multiple sources in the watershed to the point where they are discharged into receiving waters. In this way, modeling can be used to help determine how to best balance growth and water quality. Figure 1 is a simple schematic of typical watershed model inputs and outputs.

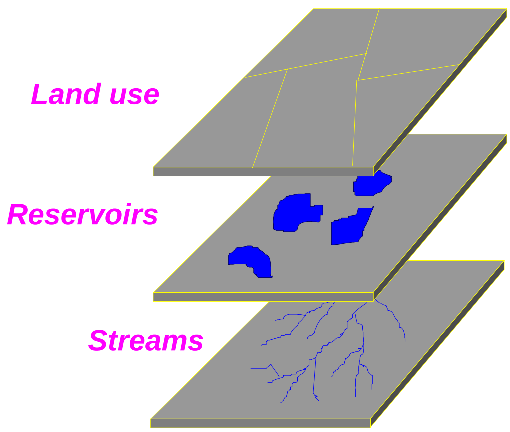
Figure 1. Watershed Model Inputs and Outputs



Watershed models use information detailing characteristics of land throughout a drainage basin. Geographic Information Systems (GIS) can be used to provide an automated method to access and use these data. Data describing features such as land use, stream networks, and soils characteristics may be available in a GIS format (Figure 2) and can be readily input into many types of models. Other data, such as that collected from stream gauging sites and weather stations located within the study area, can be used to more accurately simulate watershed response. Selection of a particular

watershed model will dictate the type of data that is needed thus will affect the scope of the water quality monitoring plan.

Figure 2. Examples of GIS Data Layers



Types of Watershed Models

Watershed models differ in their level of complexity. Simple models predict watershed flows and pollutant loads on an annual time-frame using data obtained from published sources for other sites. Complex models can generate results on hourly time intervals using site-specific data. The selection of a suitable model depends on project needs and the availability of resources such as man hours required, data and budget. Three levels of watershed models are discussed below: simple complexity models, moderate complexity models, and complex models. The watershed model selected for the Alcovy project (see Appendix A) falls within the category of complex models.

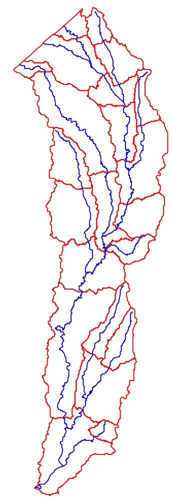
Simple Complexity Models. The simplest approach to watershed modeling does not consider runoff flow or concentration of pollutants. Estimates of total pollutant loads are based upon empirical correlations from similar studies of observed loading rates from other watersheds with similar characteristics. These models are designed to generate output for longer time periods (e.g., seasonal or annual) since data are lacking for estimating storm-specific loads.

An example of a simple complexity model is a spreadsheet model in which empirical unit area pollutant loads are used in conjunction with land area to generate seasonal or annual pollutant loads.

Moderate complexity models. Moderate complexity models estimate runoff quantity and quality, but are not necessarily calibrated to specific watershed conditions. Flows are modeled on a daily basis and are dependent on rainfall, land characteristics, runoff curve numbers, evapotranspiration

and groundwater flow. Runoff concentrations are specified by the modeler, based upon measurements (or literature estimates) of land use-specific runoff concentrations. Moderate complexity models estimate loads on an annual, seasonal or monthly basis and are the simplest types of models that can estimate daily variations in pollutant loads. Examples of moderately complex models include:

- Stormwater Intercept and Treatment Evaluation Model for Analysis and Planning (SITEMAP)
- Generalized Watershed Loading Functions (GWLF) Model
- Urban Catchment Model (P8-UCM)
- Automated Q-ILLUDAS (AUTO-QI)
- Agricultural Nonpoint Source Pollution Model (AGNPS)
- Source Loading and Management Model (SLAMM)



Limno-Tech, Inc., the modeling consultants for the Alcovy project, has used a modified EPD approved version of the GWLF model in several watersheds in Georgia including Lake Lanier, Little River (Cherokee Co.) and Pumpkinvine Ck.(Paulding Co.).

Complex models can be the most accurate, but require large amounts of data for their proper use and calibration.

Complex Models. The most complex models simulate both runoff quality and quantity and are calibrated to a specific watershed. Such models are capable of simulating a single watershed or a system of connected watersheds. Complex models can simulate runoff on an hourly or daily basis depending upon data inputs, and flows can be routed between channel segments. Complex models can account for pollutant accumulation and decay, if desired by the user. Complex models can also simulate a special event occurring within a watershed such as a particular land use activity. BASINS/NPSM (Better Assessment Science Integrating Point and Nonpoint Sources/Nonpoint Source Model) is an example of a complex model. Additional information about model selection is given in the case study presented in Appendix A. An EPA document (EPA, 1997) gives a more thorough review of watershed models and model selection.

Selection of modeling parameters. An important step in modeling is the selection of the water quality constituents to be modeled. While it may not be practical to model all of the water quality constituents that were measured as part of the watershed assessment, careful selection of model parameters can facilitate informed decision-making through modeling. Several factors can be considered for model parameter selection, including:

- Input from the technical advisory committee
- A review of listed water impairments in the study area
- Availability of data for model calibration
- budget and time constraints

WATERSHED CHARACTERIZATION AND ASSESSMENT

Basic elements of a comprehensive assessment include:

- ***Gathering background information,***
- ***Data collection,***
- ***Water quality monitoring,***
- ***Defining water quality screening levels,***
- ***Watershed modeling and evaluation of watershed protection tools, and***
- ***Development of a Watershed Protection Plan.***

The first step to developing a watershed protection plan is to understand existing conditions, including current land uses, and other factors in the watershed that could potentially affect water quality. A comprehensive watershed assessment may be necessary to achieve multiple regulatory and other long-term planning and protection goals across a particular region. The primary objectives of a watershed assessment are to:

- Meet regulatory requirements for wastewater discharge
- Build a working database that accurately reflects current land use, water quality, hydrology, and channel and aquatic habitat conditions
- Model the impact of future point and nonpoint source influences on water quality

Water quality and flow data are collected throughout the watershed assessment to characterize existing conditions in the watershed and to provide an initial data set for model calibration. Additional monitoring data can supplement existing water quality and flow data in the watershed to develop a watershed-specific model that can be used as a tool for future land use planning decisions.

The following sections describe the assessment elements in further detail.

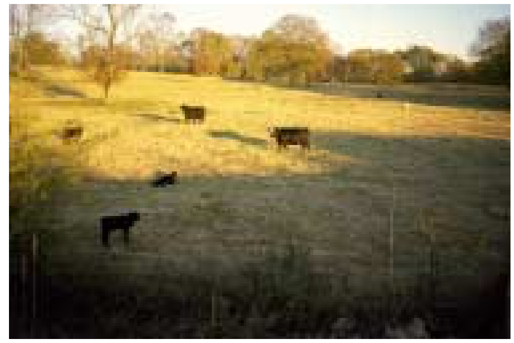
Gathering Background Information

Assimilating background information is necessary to “set the stage” for conducting the watershed assessment and to gain a more comprehensive knowledge of the watershed and the factors that influence water quality.

An understanding of the physical and ecological characteristics of the watershed and historic land use is fundamental to the successful outcome of the watershed assessment.

Examples of the types of background information necessary for conducting a watershed assessment include:

- Identification of the watershed assessment area
- A delineation of the watershed and its sub-basins
- Current land cover/land use
- Water withdrawal summary and locations of drinking water sources within the watershed
- Location and summary of permitted wastewater discharges
- Historic land uses and an understanding of their effects on present day hydrology and water quality
- A description of the natural features of the watershed including physiography, geology, soils, surface and ground water recharge areas
- Identification of unique areas, habitats and species of concern
- Identification of potential threats to water quality (e.g. urbanization)



Data Collection

Data collection involves assimilation of existing water quality data, reports and other investigations, as well as implementation of a water quality monitoring plan for collection of additional needed data.

Potential existing sources of data include:

- USGS maps, gauging station data and water quality investigations
- BASINS/STORET/ and other national clearinghouse databases
- GA/EPD 305(b) Water Quality Monitoring Reports
- GA/EPD Permit Data (NPDES, LAS, landfills, etc.)
- County government information (e.g., land use)
- Water treatment plant discharge monitoring reports
- Water reclamation facility discharge monitoring reports
- EPD water quality investigations
- University or other water quality research

Water Quality and Flow Monitoring

Water quality and flow monitoring are often necessary to complement existing sources of data in the watershed. USGS gauging stations are often located on larger streams and rivers. Therefore, smaller tributary sites should be considered for additional monitoring to capture streamflow response and water quality effects in smaller sub-basins.

Chemical measurements of water quality can be useful but provide only a "snapshot" of water quality at the time of sampling.

Defining objectives and approaches. One of the difficulties associated with nonpoint source pollution control is the limited feasibility of directly determining an accurate cause-effect relationship between land use and water quality. The EPD guidance for conducting watershed assessments requires a biological monitoring component for streams as part of a multi-metric approach for assessing watershed and stream health. The approach to watershed assessment, therefore, should include multiple assessment techniques to monitor chemical, physical, and biological conditions.

Developing a monitoring plan. The plan should include, at a minimum, the following information:

A monitoring plan should be developed prior to beginning data collection and monitoring.

- Scope and purpose
- Sampling locations
- Sampling parameters and methods
- Field procedures
- Water quality sample collection methods
- Quality control procedures, including:
  - Field procedures
  - Internal lab procedures
  - Review of Analytical Results
  - Data Management
  - Sample Handling and Custody Requirements
- Identification of sampling team
- Monitoring schedule

Site selection. Monitoring sites should be selected in representative reaches of the river and its tributaries. Other considerations for site selection include:

- Spatial distribution across the watershed (tributaries and main stem)
- Proximity to wastewater outfalls and drinking water intakes
- Location of other water quality monitoring sites (e.g., USGS stations)
- Representation of land uses and other influencing factors
- Accessibility

Selection of monitoring parameters. The decision on what water quality constituents or parameters to monitor can be confusing. However, an understanding of the relative importance of each and their relation to other constituents can simplify the process. Several primary constituents are highlighted below. A description of other commonly-considered water quality constituents is given in Appendix B. Parameter selection is often driven by model requirements.

An understanding of the importance of each water quality monitoring parameter will simplify the process of deciding what to test for and will help minimize unnecessary costs.

Flow. Flow is required for modeling the transport of constituents through the watershed and to calculate their loadings to receiving waterbodies. Flow itself can also be considered a type of pollutant in developing watersheds. Increases in paved surfaces decrease the infiltration of rainfall and produce rapid runoff and higher stormflow volumes. Erosive stormflow velocities degrade stream channels by scouring the channel bed and banks and re-suspending in-stream sediment. A comparison of flow under different future land use scenarios can be used to assess the relative impact such land management strategies may have on the hydrologic response of the watershed and on relative pollutant loadings.

Sediment. Sediment is perhaps the single greatest contributor to nonpoint source pollution throughout much of Georgia. It originates in the watershed from land disturbing activities such as clearing, grading and plowing. It is also present in significant quantities within stream channels themselves. Early settlement agricultural practices resulted in a tremendous delivery of sediment to floodplains and streams.

Sediment adversely impacts in-stream aquatic habitat, alters flow patterns, and is a transport mechanism for nutrients, pesticides, metals and bacteria.

Much of this "legacy" sediment remains in the river system today where it is continually re-mobilized and deposited downstream. Increases in stormflow often accelerate in-stream erosional processes. Because many other water quality constituents are closely associated with sediment,

parameters such as total suspended solids (TSS) and turbidity , that are indirect measures of sediment in the water column, are usually considered primary parameters for monitoring as well as modeling.

Phosphorus is often the nutrient limiting algal growth in Georgia waterbodies.

Phosphorus. Phosphorus is a water quality parameter of concern particularly for ponds and reservoirs. Agricultural, domestic, and industrial wastes are common sources of phosphorus to surface waters. Phosphorus from solid wastes and P-based detergents are common sources in municipal wastewater that may enter the stream from point sources such as wastewater plant discharges or combined sewer overflows. Fertilizer runoff from lawns and landscaped areas, detergents from car wash and other areas, septic system leachates, transported sediment, animal manure runoff, and atmospheric deposition are potential nonpoint sources of phosphorus in a watershed. Water quality standards for nutrients such as phosphorus will be forthcoming for waterbodies statewide. An understanding of phosphorus sources and loading delivery rates to streams and will facilitate equitable development of policy for nutrient criteria.

Nitrogen. Nitrogen is an essential nutrient needed to maintain a balanced aquatic ecosystem. However, when present at high levels, it can lead to a number of water quality problems including excess aquatic plant growth, depressed oxygen levels, and a change in aquatic species diversity. Higher levels of nitrates in drinking water can cause “blue babies” (Methemogloginemia) in infants. Ammonia, normally associated with municipal discharges, can be toxic to aquatic organisms.

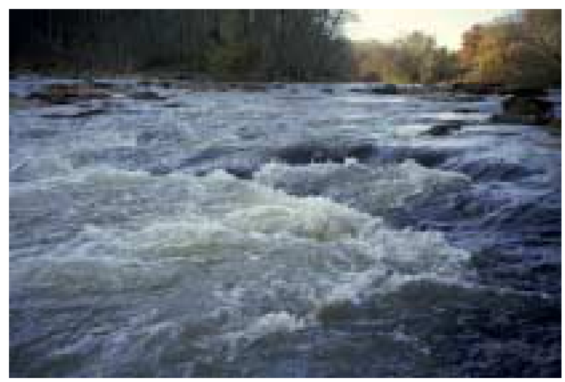
Primary sources of organic nitrates include human sewage and livestock manure, particularly from feedlots and other areas of concentrated animal waste. In urban settings, other organic sources include organic debris from yards, garbage disposal waste, and ammonia-based household cleaners. Nitrogen in sewage and septic effluent is primarily in the form of ammonia.

Fecal Coliform Bacteria. Fecal coliform bacteria is a common constituent of concern for streams, rivers and lakes state-wide. Many streams and rivers across Georgia are on the list of impaired waterbodies due to fecal coliform bacteria. Fecal coliform can be present in elevated concentrations in both natural and disturbed watersheds. Sources are often difficult to identify and may include leaks and overflows from sewer distribution systems, leaky septic systems, agricultural operations (e.g. dairy, swine and poultry), and wildlife. Fecal coliform is important from a human health standpoint as it is an indicator of disease-causing organisms.

Biological assessments are based on the premise that the structure and function of aquatic communities provide critical information about the quality of surface waters.

Biological monitoring. Biological monitoring can reveal the cumulative effect of point and nonpoint source pollution to streams and rivers. Results can be used to assess the ecological health and integrity of a particular waterbody. The Georgia Rules and Regulations for Water Quality Control, Chapter 391-3-6, define biological integrity as "the condition of the aquatic community inhabiting least impaired water bodies of a specific habitat measured by community structure and function."

A comprehensive biological sampling approach is often utilized in watershed assessments. This involves a three-pronged approach that includes habitat assessment, benthic macroinvertebrate sampling, and fish community sampling. Reference sites are selected and sampled in conjunction with study sites to provide a basis for comparison. The purpose of reference sites are to provide the "least impacted/impaired" baseline by which to compare study data and represents the "best attainable" conditions for the comparable water bodies under analysis.



Habitat assessment allows for 1) the evaluation of the quality and structure of the surrounding habitat that influences the survival of aquatic biota, and 2) the identification of potential non-water quality related factors of biological impairment. Habitat assessments reveal the quality and structure of in-stream habitat and surrounding channel and riparian conditions that influence aquatic biologic communities. Procedures involve a visual evaluation of physical habitat parameters including instream cover, substrate, channel morphology and flow, bank stability and vegetation, and riparian zone condition.

Macroinvertebrate and fish communities are excellent indicators of stream health. They inhabit aquatic areas for most or all of their life cycles and can therefore reflect past and current environmental conditions. These biological communities integrate the prevailing interactions of stream flow, pollutant loadings, habitat, and the chemical quality of their aquatic environment. In essence, aquatic biota can reflect the integrated effects of upstream watershed activities (i.e. land use) on downstream channel conditions and water quality.

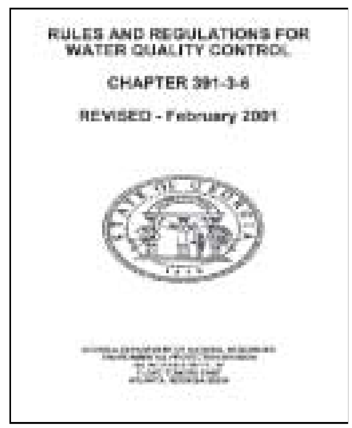
Other water quality monitoring parameters may be desirous either from a regulatory standpoint, or for an improved understanding of watershed response. For example, the Safe Drinking Water Act Amendments of 1996 require EPA to evaluate the risk to public health posed by drinking water contaminants, including waterborne parasites such as *Cryptosporidium parvum*. *Cryptosporidium* is a single-celled microbe contained in a group generally known as protozoa. It is a parasite that lives and reproduces in the intestines of mammals, including humans, and is potentially found in water and

other media. To implement these requirements, EPA must accurately assess *Cryptosporidium* occurrence in raw surface waters used as source waters for drinking water treatment plants, determine drinking water treatment and disinfection process needs, and set meaningful standards for drinking water. As a means to this end, EPA is requiring states to develop Source Water Assessment and Protection Implementation Plans for public drinking water sources. Sampling for *Cryptosporidium* is part of Georgia's Plan.

Defining Water Quality Goals. The following sections describe a three-step approach for arriving at specific water quality goals for watershed protection. These goals can vary depending on the regulatory requirement, season of the year, location in the watershed, and other factors. Other measures for gauging the success of the watershed protection plan are discussed in a subsequent section of this guidance.

Establishing water quality goals is a crucial first step to evaluating the results of the water quality monitoring and to assess watershed model outputs.

Existing Water Quality Standards. The EPD, in accordance with the Federal Water Pollution Control Act and the Georgia Water Quality Control Act, has published the Rules and Regulations for Water Quality Control (Chapter 391-3-6). Water quality standards are included in the rules to provide enhancement of water quality, prevention of pollution, and protection of public health and welfare. Furthermore, they are established to protect existing beneficial uses such as drinking water supplies, conservation of fish, wildlife and other aquatic life, and agricultural, industrial and recreational uses.


RULES AND REGULATIONS FOR WATER QUALITY CONTROL

CHAPTER 391-3-6

REVISED - February 2001

Water quality standards may be expressed as a numeric concentration or as a loading rate, or they may be narrative in nature. Most of these standards, such as EPA's toxic priority pollutants, have a numerical standard that is based on a toxicity threshold as defined during a critical low flow period. However, other water quality constituents, such as sediment and nutrients, do not have definitive standard, although criteria are currently being established.

Percent Exceedance of Water Quality Screening Levels. For those constituents that lack definitive numeric standards, water quality screening levels can be established that are based on literature values of known levels of aquatic impairment. These screening levels can be compared directly to monitoring results and annual percent exceedance of screening levels can be computed for each generated model output. It may be advantageous to assess dry and wet weather sample results separately to gain a better understanding of water quality dynamics in the watershed.

Reference Watersheds. A third alternative for evaluating water monitoring and modeling results is to establish a reference. The purpose of the reference site or refernce watershed is to provide the "least impacted/impaired" baseline by which to compare study data. Reference watersheds represent the "best attainable" conditions for the comparable water bodies under analysis. Reference site selection is dependent upon:

- Minimal development in the watershed
- Physical attributes (stream order, gradient, prevalent habitat type [riffle/run vs glide/pool]), in comparison to the study watershed
- Occurrence within the same ecoregion, or physiographic province and within the same riparian system

CRAFTING A WATERSHED PROTECTION PLAN

After completion of the watershed assessment and model calibration, the next step is to determine what actions are necessary to protect water resources in the future and to develop a watershed protection and implementation plan. If one or more jurisdictions choose not to participate in the plan, all or parts of the watershed may be ineligible for certain state permits, especially those that relate to water withdrawals and discharges.

A myriad of watershed protection tools exist. These tools may be classified as policy, incentive/ volunteer based, and other implementation tools. These are listed below, and are described in further detail in the fact sheets presented in Appendix C.

Policy Tools

Policy tools are new or modified ordinances that allow development while protecting water resources. These tools will ensure that water quality issues are considered while the community is making other decisions.

Improved Stormwater Management Ordinance. This is the single most effective tool for protecting water quality available to local governments. This ordinance would encourage low-impact development and would require control and treatment of stormwater discharges to not only prevent flooding, but also to minimize downstream channel erosion and to protect water quality.

Riparian Buffer Ordinance. A buffer ordinance protects land along streams, rivers and lakes, and is essential for maintaining aquatic habitat and protecting stream channels. A naturally vegetated buffer (on each side of the stream) is recommended for all permanently and semi-permanently flowing streams. Ideally this buffer should extend the width of the floodplain and include wetland areas. The ordinance should also have a provision for consideration of slope (i.e., the steeper the slope, the wider the buffer).

Conservation Subdivision Ordinance. This is an ordinance to encourage conservation subdivisions. Conservation subdivisions are developments in which houses are clustered and open space is permanently protected. This ordinance is a useful tool that gives developers an additional design option, while helping to protect water quality. Conservation subdivisions are "density-neutral" meaning that the same number of lots can fit on a given property, but the arrangement is different resulting in water quality benefits.

Transferable Development Rights (TDRs). TDRs are a tool that makes conservation planning more effective and fair to property owners. It is a system that allows landowners in regions zoned for low-density development to sell development rights to landowners in regions zoned for high-density development.

Incentive-based Tools

Incentive-based tools are another way to encourage activities that help preserve water quality. These are tools that are not mandated specifically by local or state law, but that can be attractive to planners and developers as their implementation usually results in a cost-savings and provides other benefits.

Water Conservation Programs. The implementation of water conservation programs protects water quality and aquatic habitat primarily by maintaining instream flows. Decreasing water demand lengthens the duration of supplies and helps to protect the natural hydrology of streams. Furthermore, a decrease in water consumption translates to less wastewater that is treated and discharged outside of the Alcovy River watershed. Coupled with other programs, water conservation provides a comprehensive integrated water resources protection strategy.

Land Acquisition Programs. By purchasing land or the development rights of the land (through conservation or farmland easements), greenspace acquisition can help to protect water quality, particularly if pursued on a large scale. Maintaining the natural condition of land around streams and rivers is the ideal approach to optimize water quality protection.

Alternative Wastewater Management. Wastewater management is an important component to any watershed protection plan. Evaluation of existing treatment facilities and planning for future wastewater treatment needs is critical for long-term protection of local water resources. As local jurisdictions consider alternatives to traditional sprawl development, alternative wastewater treatment systems, such as community treatment systems, should also be considered to meet economic, regulatory and water quality protection goals.

Other Implementation Tools

Other implementation tools provide a variety of options for local communities to preserve water quality while ensuring a high quality of life. Many of these options include community involvement, so that everyone “owns” the watershed and its health.

Conservation Planning. Planning for efficient development patterns on a regional scale and encouraging clustered development can have a large impact on water quality and is recommended for all jurisdictions. Infrastructure costs are reduced, thus saving taxpayer money.

Regional Planning and Cooperation. Natural systems, such as watersheds, do not follow political boundaries. Regional planning and cooperation coupled with local government action is essential to the successful implementation of watershed protection plans. A means by which to continue this cooperation, such as the establishment of a “watershed council,” can facilitate a continued discussion of implementation issues.

Continuous Watershed Monitoring and Model Calibration. Continued monitoring and updating of the model is particularly important for refining the predictions of the relative contributions of non-point source pollutants, especially as development in the watershed increases. The full benefits of some models may be realized only after at least five years of additional data are collected and the model calibrated accordingly.

Stream Restoration and Urban Retrofit. There are many areas throughout the Alcovy watershed that have degraded, unstable stream channels. While complete restoration is not possible across the watershed, areas may be prioritized according to need, feasibility and cost. Likewise, stormwater management problems may exist in urban areas. Identification and prioritization of areas suitable for additional stormwater Best Management Practices is the first step to remediation for long-term protection of water quality.

Agricultural Best Management Practices. Several government programs exist to assist farmers in preserving riparian buffers. Local governments can take an active role in setting priorities and coordinating water protection efforts with farmers and representatives of the Natural Resources Conservation Service (NRCS), the local Soil and Water Conservation District, the local extension service, and the local Resource Conservation & Development agency. A cooperative approach will allow local governments to work towards their water quality goals while minimizing the regulatory burden on the agricultural community.

Residential Best Management Practices. Downspouts, stormdrains and runoff from driveways should, to the extent possible, be directed to infiltration areas such as lawns, gardens, flower beds, or forested areas. Maintaining vegetative cover and heavily mulching with at least three inches of wood bark, wood chips, or compost will help improve the soil infiltration rate, and allow for more efficient uptake by plants. Avoid putting waste materials such as household chemicals down a storm drain. Use a broom or blower to clean outdoor decks and pavements whenever possible. This conserves

water and minimizes excess runoff to stormdrains and streams. Other "good housekeeping" tips for water quality protection in residential areas include:

- Maintaining septic systems
- Minimize outdoor water consumption
- Plant drought-tolerant vegetation
- Consider capturing rainwater for outdoor watering
- Avoid vegetative clearing around streams, riparian zones or floodplains
- Avoid channelizing streams or channels that connect to streams
- Avoid filling in floodplain or riparian zone areas
- Limit chemical application to areas outside of the stream corridor

Improved Enforcement of Existing Erosion and Sediment Control Ordinances. Existing erosion and sediment control laws are often sufficient for long-term water quality protection. Identification and protection of all environmentally sensitive areas is critical from the planning phase to project completion. Perhaps most challenging component of an effective E&SC program is enforcement. Training and certification is recommended for code enforcement staff. A comprehensive evaluation of local E&SC programs including field inspection of a variety of on-going projects is recommended. As development activity increases, additional E&SC staff may be necessary.

Community Education and Partnering. Community stakeholders can become key leaders for influencing public opinion, and are a tremendous resource for creating a springboard for long-term citizen action. Local governments can partner with existing watershed interest groups to sustain the open lines of communication established throughout the course of the project.

GAUGING THE SUCCESS OF THE WATERSHED PROTECTION PLAN

A Watershed Protection Plan should be based upon information available at the time of the study, including existing land use, future land use projections, and other assumptions. However, inevitably there will be immediate issues that influence communities that cannot be anticipated. For example, an increase in the timing and location of development activities, zoning changes, changes to existing regulations, and changes in the rate of water withdrawals and wastewater discharges, can influence the prioritization of implementation strategies. Futhermore, weather conditions may be erratic, impacting the hydrology in ways unforeseen at the outset of the watershed assessment. However, there is a need to measure compliance with the plan, despite the continuously changing conditions. The following approaches are offered to gauge the success of the Plan as well as to help determine the need for Plan updates:

- **Land Use**. Annual comparisons should be made between the actual and projected land use and the assumptions made for watershed modeling. Significant differences, such as rezonings for commercial use, would be indicated by an increase in development density and amount of impervious surface area. If significant differences occur, the model should be re-run to determine the relative impacts on water quality. If the model shows that the land uses have or will adversely impact water quality, it may be necessary to implement additional water quality protection tools.
- **Enactment of Ordinances.** Policy recommendations deemed vital to the success of the Plan should be implemented first. Communities should document enactment of the ordinances as evidence of compliance with the Plan.
- **Analysis of water quality data.** Long-term water quality and flow monitoring throughout the watershed are vital to gauging the success of the Plan. These data should be compiled in a common database, analyzed for trends and indications of water quality, and used to improve the model calibration.
- **Regional Cooperation and Community Education**. The formation of a Watershed Council, is recommended to gauge the success of implementation of the Watershed Protection Plan. The Council should capitalize on the successful partnering effort begun with the watershed assessment between regulatory agencies, local officials and community groups. The Council should continue the dialogue between jurisdictions and would encourage upstream and downstream neighbors to work together to address common watershed issues. The council should provide quarterly or bi-annual progress reports to the elected officials and the public on watershed plan implementation.

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APPENDIX A

THE ALCOVY RIVER WATERSHED PROTECTION PROJECT: A CASE STUDY FOR A REGIONAL APPROACH TO WATERSHED ASSESSMENT AND PROTECTION

PROJECT OVERVIEW

The Alcovy Project is one of the first comprehensive regional land use and water quality studies in Georgia. The Alcovy is a 292 square mile (~187,000 ac) watershed located east of Atlanta, Georgia within the Upper Ocmulgee Basin. The watershed spans four counties from its headwaters downstream to Jackson Lake and supplies water to surrounding areas from four drinking water intakes. In addition to serving as a reliable drinking water source for surrounding communities, the Alcovy River system and its reservoirs provide a multitude of recreational opportunities such as hiking, fishing, boating, and hunting. The Alcovy River is also home to some of the most unique alluvial swamps in the Georgia Piedmont. Land use is mostly rural and includes a mix of agricultural and forested areas. Urban areas are growing around cities situated mostly near the headwaters and watershed boundaries.

The area is anticipated to experience rapid growth in the coming decades as Atlanta continues to expand into surrounding counties. The close link between water quality and land use dictated the need for a plan that integrates vision for growth and development with water quality protection as cities and counties in the Alcovy watershed continue to grow.

Multiple regulatory requirements created the need for a watershed study that overlapped jurisdictional and political boundaries. Source water assessments and watershed protection measures are required for water supply watersheds above raw water intakes; watershed assessments are required for new and expanding wastewater discharge permits. Land areas upstream of stream segments that are not meeting their designated uses as determined by the state will be subject to pollutant loading restrictions. Individual construction sites are faced with new regulations for sediment control and runoff.

Recognizing the benefits of a regional, watershed-based approach, the four counties and 11 municipalities within the basin agreed to cooperate to fund the study (Table A-1). The project was coordinated through the Northeast Georgia Regional Development Center (RDC) with oversight from a Policy Committee and Technical Advisory Committee (TAC). Brown and Caldwell was the lead consultant and provided project oversight and coordination. Limno Tech Inc. provided modeling services, and the University of Georgia's Institute of Ecology Office of Public Service and Outreach provided policy research and technical support (Figure A-1).

Financial support was provided by the Georgia EPD and each of the participating counties according to relative land area and population represented within the watershed (Figure A-2).

The project was intended to be the first step for the long-term protection of water quality and water supplies in the watershed.

Table A-1. List of Counties and Municipalities Participating in the Alcovy Watershed Protection Project

Counties	Land Area within the Alcovy River Watershed (acres)	Land Area within the Alcovy River Watershed (percent of total)	Municipalities	Land Area within the Alcovy River Watershed (acres)	Land Area within the Alcovy River Watershed (percent of total)
Gwinnett	41,777	21%	Dacula	561	0.3
			Lawrenceville	2,812	1.4
			Grayson	421	0.2
Walton	84,598	42%	Loganville	1,661	0.8
			Between	556	0.3
			Monroe	2,929	1.5
			Walnut Grove	317	0.2
			Jersey	500	0.3
			Social Circle	3,758	1.8
Newton	62,435	31%	Covington	2,123	1.0
			Mansfield	314	0.2
Jasper	11,041	6%	--	--	--

Figure A-1. Diagram of Project Management Strategy

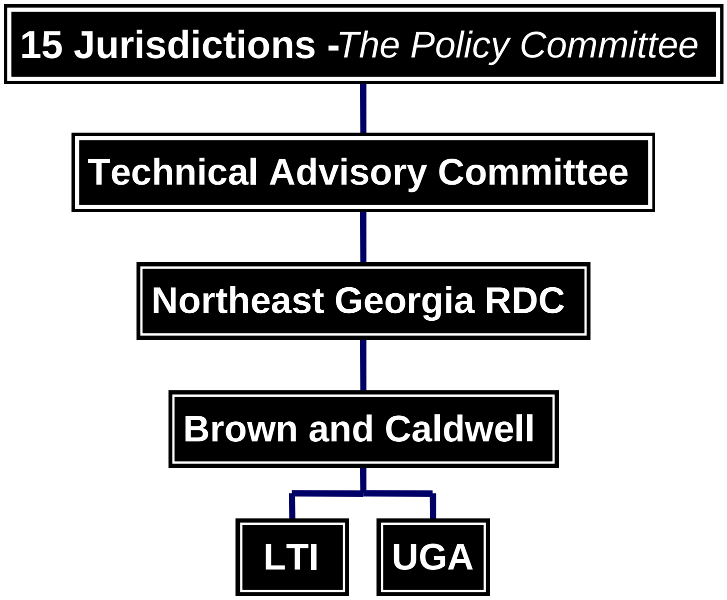
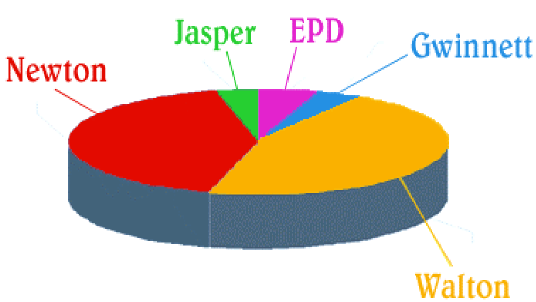


Figure A-2. Relative Contribution of Funding to the Alcovy River Watershed Protection Project



The project consisted of several complimentary components:

- A ***watershed assessment*** that included data collection, hydrologic and water quality monitoring, and development of a watershed model

- Four ***source water assessments***, prepared in accordance with Georgia's Source Water Assessment and Protection Implementation Plan (SWAPP) for Public Drinking Water Sources
- A ***watershed protection plan***, which included recommendations for new or improved local ordinances, best management practices, and continued regional cooperation and public involvement

All cities and counties participated in the development of the watershed protection plan. However, Gwinnett County had previously conducted a separate watershed assessment, prepared a protection plan, and was already underway with implementing various components of their plan as the Alcovy project was ending. Coordination with the Gwinnett work was a challenge throughout the Alcovy project and demonstrates the difficulty with conducting such projects within the confines of political, rather than watershed boundaries.

DEVELOPING A COOPERATIVE APPROACH

This section presents the timeline of events, participants, and discussions leading up to the inception of the Alcovy Watershed Protection Project. This project provides one example of how to develop a cooperative approach across political jurisdictions and multiple regulatory agencies for undertaking a regional watershed assessment and creating a comprehensive watershed protection plan.

Bringing People Together

On March 27, 1998, a meeting was hosted by the Georgia Department of Community Affairs (DCA) and the Georgia Environmental Protection Division (EPD) in Gwinnett County to open discussions of the possibility of a basin-wide study of water quality protection for the Alcovy River watershed. The immediate focus of this meeting was the protection of the water supply watershed above the Monroe surface water intake, parts of which lie in Gwinnett and Walton Counties, and the cities of Dacula, Lawrenceville, Grayson, and Between. Some of the governments represented had been issued deadlines by DCA to implement watershed protection measures for this particular watershed, while others had not yet received such notifications. The meeting's purpose was to explore the possibility of working together on developing a joint watershed protection plan as an alternative to the watershed minimum guidelines (Part V Criteria of the Georgia Planning Act), following the example of the Big Haynes Creek planning effort.

The idea met with positive response, with representatives of Newton County, the City of Covington, Jasper County, and the Walton County Water and Sewerage Authority suggesting that the scope of the effort should include the whole Alcovy Watershed as far downstream as Jackson Lake. The consensus of the meeting was that:

- A basin-wide study should be explored
- The Northeast Georgia Regional Development Center would take the lead in facilitating the activity with the cooperation of the Atlanta Regional Commission
- EPD and DCA would attend future meetings and provide technical assistance

A second meeting was held in Monroe, Georgia, on May 11. The meeting resulted in deciding the following:

- The scope would be limited to direct examination of watersheds within the Alcovy Watershed, although some attention would be paid to other contributors to water quality of Jackson Lake

- Ongoing efforts by Gwinnett County would be coordinated with new studies
- The general structure followed by the Big Haynes group of having a technical committee and a policy committee would be appropriate
- EPD would have to answer questions about how all the different water quality programs fit together
- A smaller ad hoc committee would be formed to develop a plan of action for initiating the project

The ad hoc committee[1] met several times with representatives of EPD and DCA over the next few months, including a meeting with Commissioner Harold Reheis. The Environmental Protection Division operates multiple programs relating to non-point source water quality and local governments. The Department of Community Affairs administers the environmental planning criteria specified by the Georgia Planning Act. Each program could have different requirements, and the group sought assurance that a plan that satisfied one or some of these programs would not have to be re-done or supplemented with additional work later to satisfy different criteria for another program. The EPD agreed to coordinate its programs with the Alcovy work so that the resulting plan would indeed satisfy all water quality requirements.

In addition, the group wanted to know if a plan could be approved if one or a few jurisdictions failed to participate or to implement it. It was learned that EPD considers basin-wide cooperative planning to be so valuable that “gaps” in their coverage need not make the plan non-viable. Furthermore, EPD will use its permitting and enforcement powers to encourage implementation of a plan once it is adopted. EPD offered to make every effort to encourage cooperation by each government in the basin.

The Department of Community Affairs agreed to suspend the watershed protection deadlines pending development of a schedule and scope of work for an alternative to the environmental planning criteria. If the governments agreed to a reasonable planning schedule, DCA would incorporate them into its requirements for compliance. If no planning schedule was agreed upon, DCA would then reevaluate a deadline for Part V Criteria for affected governments.

[1] The committee comprised two representatives from each county: Steve Logan & Frank Stephens, Gwinnett; Frank Sherrill & Mark Ennis, Walton; Tom McLean & Glen Kell, Jasper; John Byce & David Croom, Newton. They were assisted by staff from the Northeast Georgia Regional Development Center, the Atlanta Regional Commission, EPD, DCA, and the Soil and Water Conservation Districts.

Obstacles to Getting Starting

The major obstacle to creating a cooperative regional watershed study for the Alcovy project was funding. The cost for conducting a comprehensive watershed study to address multiple regulatory requirements across four counties was significant. Since regulatory requirements for watershed protection were largely unclear at the time and issues such as source water protection and TMDLs were just beginning to emerge, some jurisdictions needed additional justification for conducting such a study. The ultimate incentive for agreeing to fund this study came from the desire from those counties and municipalities downstream to have a voice in protecting water quality from potential upstream threats.

Developing a Plan of Action

The planning group proceeded to draft a schedule of activities for both the technical and policy processes for local governments. The committee drafted a cost allocation method based on land area within the basin (50%) and population (50%). For jurisdictions receiving water from the Alcovy River or its tributaries, all of the population was used; for jurisdictions not receiving water, the estimated population within the watershed boundaries was used. At the time, Gwinnett County was in the midst of a multi-million dollar water quality assessment study and planning effort for the entire county. It was the opinion of the planning group that the portion of work necessary for the Alcovy Watershed Study in Gwinnett County was already being done. Therefore, the group estimates that roughly $260,000 was being spent by Gwinnett County toward the protection of the Alcovy. In the cost allocation formula, therefore, Gwinnett County was assigned a relatively small amount as its share of work was not duplicated by the ongoing effort. The committee also drafted a memorandum of agreement to submit to local governments for adoption by resolution committing their support for the planning process.

A meeting of representatives from each potentially participating jurisdiction was held on November 6, 1998 in Newton County. The group affirmed the cost allocation method, the schedule of activities, and the text of the Memorandum of Understanding (MOA). The existing planning group was “rolled over” as the Technical Advisory Committee. The representatives of the various jurisdictions present, plus the chief elected officers of un-represented governments, were named as the Policy Committee.

After informal consultation with consultants experienced in water quality assessment projects, an estimated budget of $1,000,000 was established, the cost allocation method applied, and the budget, a rough scope of work, proposed organization, and the Memorandum of Understanding were sent to each potentially participating government.

The MOA was signed and returned by all four counties and six of the 10 cities. Despite not having a preliminary agreement with a few of the smaller cities, the advisory group decided to move ahead. The funding was allocated to counties, which could, at their discretion, approach participating cities to share the cost. Invoices were prepared and submitted to the four counties. Meanwhile, the process of selecting a consulting firm was begun.

Selection of a Consulting Firm

The technical committee drew up a request for proposals to conduct watershed assessments, which was published in November, 1998. Eight firms responded, and the technical committee chose four firms to prepare detailed proposals and make presentations to the committee. The presentations were heard on April 21, 1999, and the firm of Brown and Caldwell, in association with LimnoTech,

Inc. and the University of Georgia's Institute of Ecology Office of Public Service and Outreach, was chosen as the lead firm. Negotiations with Brown and Caldwell to detail the scope of work and budget were successful. This method of selecting a consultant was chosen for four reasons.

- First, the watershed approach involving multiple jurisdictions and designed to address multiple regulatory as well as local needs was, if not unique, unusual enough that the TAC did not believe they could write a detailed scope of work and simply ask for qualifications and bids
- Second, the TAC felt that they had a sufficient grasp of the needs of the study to issue a request for proposals
- Third, the TAC felt that selection of the right firm for the project would depend heavily on the approach that the firm took and not merely on their general qualifications
- Fourth, the TAC felt that preparation of a proposal for such a large and unusual project would be a significant undertaking in itself, as would proposal review by the TAC. Therefore, they did not wish to require unnecessary work for either the applicants or TAC reviewers
- The final cost for the study was not to exceed $900,000. The technical committee adopted a project budget of $1,000,000 to be spread over two fiscal years according to estimated rates of incurring costs. In May, 1999, the Northeast Georgia Regional Development Center issued requests for payment to each of the four participating counties for anticipated expenses covering the period June 1999 through June 2000

DEVELOPING LONG-TERM GOALS

The Alcovy River Watershed Protection Project was the first comprehensive water quality study of the Alcovy River. The project included goal setting, data collection, field sampling, water quality modeling, plan development, and public participation. The goals, established at the start of the project, were developed to address watershed assessment requirements, source water assessment and protection, and broader watershed protection for long-term sustainability of water supplies and water quality throughout the watershed. Goals for the project included:

- Protect water quality throughout the watershed
- Develop and implement an economical, basin-wide approach for water quality protection with flexibility for individual jurisdictions
- Provide local governments with tools to facilitate the decision-making process on planning and management issues related to water quality
- Clearly define implementable strategies that meet or exceed state requirements for long-term watershed protection, including:

- Source Water Assessment Plans (SWAPs) for protection of water supplies throughout the basin
- Watershed Assessments for increased future wastewater discharges
- Environmental Planning Criteria
- Effective measures for Erosion and Sedimentation Control (E&SC)
- Improved Stormwater Management
- Implementation of TMDLs (total maximum daily loads)

▪ Preserve the unique ecology of the Alcovy watershed and help protect Lake Jackson from further degradation

▪ Provide a working water quality model and long-term monitoring plan

▪ Foster informed public opinion about the challenges and opportunities for water quality protection in the Alcovy watershed

▪ Involve the public in watershed protection planning and implementation

▪ Work with existing organizations and programs to create the foundation for an on-going program of watershed protection

PUBLIC PARTICIPATION PROCESS

Public outreach and participation was a key component of the Alcovy Project. Communication and education about the watershed study increased the knowledge among local residents regarding watershed protection efforts, generated input on proposed policy tools and implementation options, and presented opportunities for on-going partnerships between community groups in the assessment area and participating government agencies and utilities. Input was received from over 500 people, including multiple stakeholders throughout the Alcovy River Watershed. The sections that follow describe components of the public participation process.

Forming Advisory Committees

Local jurisdictions provided support to the Alcovy Project through multiple advisory roles (Figure A-1). The Policy Committee, which consists of elected and appointed officials, guided policy elements of the project and acted as a voice for local constituents. Additionally, two individuals were selected from each county to serve on the Technical Advisory Committee (TAC). The TAC met with the consultant team on a monthly basis to oversee technical aspects of the project and to communicate project progress to county officials. The Northeast Georgia Regional Development Center (RDC) facilitated the Alcovy Watershed Assessment Protection Project process by:

- providing a forum for city and county jurisdictions to collaborate
- helping communities understand regulatory requirements
- providing data and guidance for modelers and watershed scientists

Developing a Public Involvement Plan

The Public Involvement Plan for the Alcovy Watershed Protection Project was designed to serve as a bridge between project needs and community concerns. Working from the vision expressed by the Northeast Georgia RDC and the TAC, the approach was crafted and formalized in a comprehensive Public Involvement Plan. The Plan incorporated research on attitudes and opinions of key opinion leaders, and a review of media coverage on relevant issues, in order to lay the foundation for an effective program. Goals, as developed by the NEGRDC and the TAC, were as follows:

- Employ an easy-to-understand format to foster informed public opinion about the importance of water quality in the Alcovy
- Seek to understand the values and attitudes of stakeholders
- Provide opportunities for meaningful input and feedback on recommended solutions
- Create a foundation for ongoing programs supporting citizen involvement in Alcovy water protection
- Design and employ a basin-wide approach with flexibility for individual jurisdictions
- Incorporate public input into the Approved Management Plan, and encourage broad-based support for Plan implementation

The overriding message throughout the public involvement phases of the Alcovy Watershed Protection Project emphasized the protection of the river and its tributaries as a valuable natural resource and the regional approach necessary for long-term protection. All of the jurisdictions and agencies within the four counties participating in the project acknowledged the need to work in concert, and committed to developing a comprehensive plan to protect water supplies, water quality, and the unique ecology of the Alcovy River system.

Local residents were brought onto the team to extend these protection efforts beyond regulatory requirements. The message, reflecting this cooperative effort, was: ***TEAM ALCOVY: NEIGHBORS FOR CLEAN WATER.*** The fundamental concepts woven into the message were:

- A cooperative spirit among neighboring jurisdictions and agencies ensure a regional effort to water protection
- We all have an impact on the Alcovy's quality, and we can all be part of preserving it
- Protection strategies uniquely suited to each community help all communities protect this precious shared resource

Mechanisms for engaging stakeholders were discussed prior to implementation of the Public Involvement Plan. The resulting Plan employed a comprehensive approach to encourage the public to participate in developing a watershed protection program that could be successfully implemented for the Alcovy River. As the project moved forward, this Plan evolved and reflected the direction necessary to ensure the process was on track. Discussed below are the components of the Plan.

Stakeholder Interviews. A list of stakeholders was developed based on input from the NEGRDC staff, the TAC, participating governments, and other relevant sources. Stakeholders are those members of the community having significant involvement or interest in the watershed study project. From this list, 15 of the identified stakeholders were selected by the TAC to be contacted for an informal interview. The goal of the interviews was to garner suggestions on how to best engage the public in the process, and to solicit input on groups that should be contacted for scheduling of informational presentations and input sessions about the project. The

stakeholders participating in the interviews represented a variety of backgrounds and interests, including developers, farmers, planners, environmentalists, academics, concerned citizens, etc. These individuals provided valuable information about concerns of interest to particular communities and jurisdictions, as well as guidance on how to reach interested residents within the watershed. Interview summaries were provided to the TAC for consideration in the planning process.

Public Meetings. The BC team conducted three public meetings during the course of the Alcovy Watershed Protection Project. Announcements about these meetings were placed in the form of paid advertisements in the major newspapers within each jurisdiction. In addition, notices were mailed to the stakeholder list and were posted on the project website. The first public meeting was conducted shortly after project startup to provide an overview of the study and address any initial concerns from the public. The second was held at the project midpoint to provide more in-depth findings from the study, and solicit specific responses to proposed policy tools such as conservation subdivisions, increased enforcement, etc. The third was conducted near the conclusion of the study after sampling and data results had been analyzed, requesting comments and additional feedback. All three meetings were reasonably well attended, and residents took advantage of the opportunity to provide their specific concerns and issues, as well as ask questions related to their particular interests.

These meetings were open to the general public and featured an open house format. Manned information stations provided specific information on implementation options for watershed protection and provided an opportunity for one-on-one discussions with the public about these and other issues. Presentations and subsequent discussions were also part of the meeting format and provided a means to relay project information and results and to solicit other comments and questions. These meetings served as a complement to the next component of the Public Involvement program, Community Presentations.

Community Presentations. The Brown and Caldwell team conducted more than 15 community presentations throughout the course of the project. Community groups included local rotary and garden clubs, cattleman's associations, and many others. These meetings were scheduled by contacting various community groups identified through the stakeholder interview process, and from recommendations of the TAC. Following guidance from the TAC and the Policy Committee, policy concepts relevant to the recommendations of the watershed protection plan were introduced to identify and address the specific needs of each community. Presentations typically consisted of a 15-minute slide show presentation, followed by a question/discussion period, and in some cases, including a written survey asking for responses to questions related to the challenges and opportunities for long-term watershed protection and preferences of various implementation options.

Newsletter Articles/Press Releases. The BC team developed and distributed press releases to be included in community newsletters and local newspapers. Articles focused on project overviews, project updates, data results, computer modeling, and potential implementation strategies. Press releases were also forwarded to all major media in the watershed study area throughout the duration of the project detailing project milestones and announcing all public meetings.

Web Site. The BC team developed a publicly accessible web site providing project-related information (www.teamalcovy.com). The web site was a valuable tool in providing timely information to the public. It included information about upcoming community presentations, public meetings, and other news of interest. The site also included an extensive sampling data section which provided scientific sampling data for all of the river sampling sites, as well as easy to understand explanations for the findings.

Reaching Elected Officials. A policy committee was formed at the beginning of the project to act as a general steering committee for the project. This committee was composed of elected officials and other representatives from each participating jurisdiction. Meetings were held to identify issues of concern and at the end to gather input on recommendations. Presentations were also given to various planning commissions and regular commission meetings at intermediate stages of the project.

MODEL SELECTION

Watershed modeling was an integral portion of the Alcovy Watershed Protection Project. The overall goal of the watershed modeling was to develop a tool that can define acceptable land use and/or best management practices that will result in attainment of water quality objectives. This tool must meet the needs of both the TAC and the Georgia DNR/EPD. The project team interviewed the TAC to better define their management objectives for the modeling. The following sections detail the factors that were considered for model selection.

Model Objectives

The Project Team interviewed the TAC regarding many factors that can influence model selection including:

- Consistency with other local applications
- Stakeholder approval
- User interface
- Groundwater quality
- Model constituents
- Spatial and temporal resolution
- Reliability

Consistency With Other Local Applications

How important is it to select the same watershed modeling approach that is being applied in the majority of adjacent watersheds? The TAC believed that consistency was very important. The Northeast Georgia RDC is not currently running models for other watersheds. There is agreement within the TAC that the Northeast Georgia RDC will be the entity that runs the model. The Northeast RDC will also be responsible for maintaining the model when the project is complete. There is a desire to have some consistency across the models supported by the RDC. However, recognizing that different watersheds will have different resources available, the RDC also needs the flexibility to support a range of model complexities (including limited or no modeling). There is some desire to have consistency with the model application already developed for the Gwinnett County portion of the watershed, but this should not be viewed as the primary determinant of model selection.

Stakeholder Approval

What stakeholders will be required to approve the selected model? The TAC made the final selection of the model with input from EPD, based upon recommendations from the project team. Input for model selection was not solicited from others.

User Interface

How important is it that the selected model contain a user-friendly interface that will allow the TAC to evaluate additional scenarios without consultant assistance after project completion? A user-friendly interface (with user friendly inputs and outputs) that allows the TAC to perform additional scenarios without consultant assistance after project completion is an important model feature.

Groundwater Quality

Is the capability to simulate changes in groundwater quality important? The capability of the model to simulate changes in groundwater quality is not an important enough model feature to invest additional resources in its development for the Alcovy project.

Model Constituents

What are the water quality constituents of concern? At a minimum, the model must be capable of predicting the concentration of those constituents that have been listed as impairing water quality in the watershed. The model should also be able to provide predictions for other parameters that are of concern to the TAC such as metals, nutrients, sediment.

Spatial and Temporal Resolution

What is the required spatial detail of model predictions and what are the required time scales? For the river, a one-dimensional (1-D) model that can make predictions on the scale of hundreds of feet was sufficient for this study. A 1-D model will predict changes in concentration along the length of the river, but will not consider lateral or vertical variations in water quality. For the reservoirs (Beaverdam Creek and Cornish Creek Reservoirs), an empirical model that assumes complete mixing was sufficient. Only the Alcovy arm of Lake Jackson was be simulated. Continuous simulation with a daily time step was used to estimate watershed loads.

Reliability

How reliable should the model be? The TAC expressed a desire to focus on the model with the greatest long-term accuracy as opposed to the model that provides the most "bang for the buck" at the end of the study.

Model Comparisons

This section describes the ability of two models to meet the objectives stated above. Although only two models are presented, it is important to know that they models were selected from the suite of models reviewed in the EPA Compendium of Watershed-Scale Models for TMDL Development (EPA, 1997). Model selection was based on prior experience with these models, performance of

these models, their ability to meet the model objectives outlined in this memorandum, and their acceptability to EPD.

GWLF – Generalized Watershed Loading Functions. GWLF is a model with a moderate level of complexity which has been approved by EPD and which performed well when compared to measured data. A modified version of GWLF has been used previously in the Lake Lanier watershed and is currently being used within Cherokee County, Georgia.

GWLF is capable of meeting a majority of the objectives described above, and will provide as much or better accuracy than BASINS/NPSM if applied only with the data to be collected during this study. It can be applied using a level of effort less than currently allotted in the existing budget. Its primary limitation is that its level of accuracy can not be greatly improved in response to additional future monitoring, giving it a lower potential future accuracy than the more complex BASINS/NPSM model.

BASINS/NPSM - Better Assessment Science Integrating Point and Nonpoint Sources/ Nonpoint Source Model. BASINS/NPSM was developed by the EPA specifically to address multiple land use effects on water quality including both point and nonpoint sources of pollution. BASINS/NPSM is a model with a high level of complexity, based upon the well-accepted Hydrologic Simulation Program – Fortran (HSPF) watershed model. BASINS/NPSM is currently being used within Georgia (i.e. Fulton County, Gwinnett County and elsewhere). This model has been approved by EPD and has also performed well when applied with sufficient monitoring data. It is capable of distinguishing between sediment that is washed off from land surfaces and that which is re-suspended within a given channel reach, thus partitioning sediment loadings accordingly.

BASINS/NPSM is also capable of meeting a majority of the objectives described above. The strongest factor favoring the use of BASINS/NPSM is the potential for future accuracy much greater than the GWLF model. This improved accuracy can be achieved only in response to a long term (i.e., at least six years) monitoring effort and additional calibration effort. It must be recognized that BASINS/NPSM contains more complexity than can be supported by the existing monitoring effort. If the resources are not available to support this long-term effort, BASIN/NPSM will provide accuracy similar to or slightly less than GWLF at a higher overall cost (although still consistent with the model budget).

Model Recommendations

Management objectives outlined by the TAC were used to guide the model selection process. These objectives included selection of a model which:

- is consistent with other applications in Georgia
- contains a user-friendly interface

- is approved by the Georgia EPD
- has the ability to simulate constituents of concern on a continuous basis
- and has the greatest long-term accuracy

Two models, BASINS and the LTI-modified version of GWLF, were identified as being capable of meeting the majority of the management objectives outlined by the TAC. GWLF was believed to provide the higher reliability for this phase of the study, as it has lesser data needs which are more consistent with the amount of data available during the time of the study.

However, BASINS/HSPF was selected primarily because it provides the potential for the greatest long-term accuracy. It was recognized that this model contains more complexity than can be adequately supported by the existing monitoring effort. The full benefits of the model will be achieved only after at least six years of additional data are collected and the model calibrated accordingly.

THE ALCOVY RIVER WATERSHED ASSESSMENT

The assessment of existing conditions included historical data collection, base flow and wet weather field sampling, biological field data collection and habitat assessment. Water quality and flow data were collected to characterize existing conditions in the Alcovy River watershed and to provide initial data for model calibration. Monitoring data supplemented existing water quality and flow data in the watershed and were used to develop a watershed-specific model that could be used as a tool for future land use planning decisions.

The approach for water quality monitoring for the Alcovy watershed included:

- Gathering existing water quality and flow data in the basin
- Evaluation of the watershed for addition data needs
- Identification of sites for additional field data collection
- Collection of additional hydrologic and physical, chemical and biological water quality data

Collection Of Existing Data

Data collection involved assimilation of existing water quality data, reports and other investigations, as well as implementation of a water quality monitoring plan. Existing sources of data included:

- USGS Gaging Station Data
- Water Treatment Plant Data

- Loganville Water Reclamation Facility (WRF) Data
- EPD Water Quality Investigation of Big Flat Creek
- EPD Jackson Lake Study
- The Gwinnett Watershed Assessment
- Land use

Site Selection for Water Quality and Flow Monitoring

For the Alcovy project, sites were selected throughout the watershed for measurements of streamflow, collection of water samples for chemical analysis, and assessment of aquatic biological community and habitat conditions. Objectives of monitoring included:

- To define pollutant loads and flows for sub-basins draining various land uses
- To monitor water quality in streams not meeting designated uses
- To check existing monitoring sites
- To determine water quality in water supply watersheds
- To conduct a longitudinal analysis of water quality in the river

Fifteen sites were identified for water quality and hydrologic monitoring. Flow data and water quality samples were collected during both baseflow and stormflow conditions to capture stream response and identify the variabile concentrations of water quality constituents. A subset of sites was selected for biological monitoring, including macroinvertebrate and fish collections and habitat assessments. A reference versus study site approach was necessary for biological assessments, and therefore two additional sites were selected outside the study area for this purpose. Representatives of the Fisheries Section of Georgia's Wildlife Resources Division were consulted regarding reference site selection and recommended two sites, one to represent smaller streams, the other to represent sites located on the main stem of the river.

Flow Monitoring

Flow monitoring was conducted to provide site-specific hydrologic data for model calibration. Stream velocity and channel measurements were made during baseflow (dry weather) and stormflow (wet weather) conditions. Storm flow events were defined as any rainfall event of more than 0.10 inches in a two-hour period or more than 0.25 inches in a twelve-hour period that caused the stream to rise at least three tenths of a foot. In addition, the sampling plan required that total rainfall in the 72-hours prior to a storm not exceed a total of 0.10 inches. Manual flow

monitoring was conducted. Therefore, only instantaneous stage and velocity were obtained for each site for a given site visit. Utilization of automated flow monitoring equipment was tested in

the field. Unfortunately, it was not feasible due to problems with maintenance and sediment clogging. Staff gauges were installed at all sites to monitor the stream/river surface water levels during sampling visits. A channel cross-section location was also established at each monitoring station to serve as the permanent location for flow monitoring through the the study.

Water Quality

Water quality data was compiled from existing sources and was collected from the 15 monitoring sites located throughout the watershed. Biological assessments were conducted at selected sites. Field data collection for the Alcovy Watershed Assessment coincided with one of the driest periods on record.

For the level of development in the Alcovy Watershed, the river condition is typical. It is not as good as in a heavily forested watershed, but better than a highly urbanized watershed. When grades against the three levels of concern for evaluating river systems, the Alcovy rates as follows:

- **Public Health:** For the normal level of human contact, the river poses very little threat to public health. Following rainfall events in certain places in watershed, fecal coliform levels are elevated.
- **Cost of treating to drinking water standards:** Currently, the water quality in the Alcovy River is a very good drinking water source. As discussed further in the Source Water Assessment Reports, there are various risks upstream of water intakes that require management by the local water treatment officials. Continued protection of the river will control water treatment costs and minimize potential risks.
- **Water quality for aquatic life:** Degradation of habitat has resulted from sediment deposition.

The primary threat to stream health in the Alcovy is sediment. Fresh inputs of sediment to streams from land disturbing activities coupled with eroding streambanks contribute to elevated sediment loadings throughout the watershed. Fine sediments become suspended during stormflow increasing stream turbidity. These effects are most pronounced immediately downstream of urban areas (in the headwater streams in Gwinnett County and below Monroe) and in streams that were historically channelized. Ammonia toxicity continues to be a problem downstream of Loganville's wastewater discharge on Big Flat Creek. Assessment data confirmed its continued 303(d) listing for impairment until plant improvements, which are underway, are brought on line. Data also substantiated the fecal coliform impairments on other 303(d) segments in Gwinnett County.

Phosphorus levels were sporadically elevated across a number of sites. Elevated levels were reported during stormflow and were likely associated with sediment suspended in the water column. Fecal coliform was elevated across sites, particularly during wet weather. Concentrations at Mountain Creek below Monroe were also high during dry weather, indicating a potential source directly upstream.

Water quality data collected at the Cornish Creek Water Treatment Plant found phosphorus concentrations were in the range typically identified for mesotrophic (moderately nourished) lakes. Nitrogen levels were generally low and did not appear to pose a threat to the water quality of the lake, since phosphorus is the limiting nutrient for eutrophication. Chlorophyll *a* data was somewhat limited. However, concentrations measured during 1996 and 1997 ranged from mesotrophic to hypereutrophic conditions. This means that the lake is over-nourished, impacted by sedimentation, and that and algae/macrophyte growth is periodically high (as was observed in 1997). Such conditions are stressful to fish and are not conducive to supporting more sensitive species.

Jackson Lake is monitored by EPD for compliance with water quality standards. Average phosphorus concentrations are indicative of mesotrophic to eutrophic conditions. Fecal coliform levels are generally low. Chlorophyll *a* concentrations exceeded the state standard of 20 ug/L for 1989 and 1999, and are close to exceeding the standard for the current year 2000. A Phase I Clean Lakes Diagnostic/Feasibility Study by Georgia EPD in 1993 found that sediment deposition was occurring at a rate of 550 tons per square mile per year (1,660 lbs/ac/yr), and that the reservoir had lost approximately 40% of its storage capacity from 1910 to 1989. Sediment loads were highest from the Yellow and South Rivers and were interfering with recreational uses of the lake.

Aquatic Biota

The abundance, diversity and sensitivity of aquatic macroinvertebrates and fish were gauged against nearby reference streams. Most Alcovy sites scored in the "poor" to "very poor" range. Alcovy at Newton Factory Mill Road scored the highest for macroinvertebrates and Cornish Creek had the best rating for fish. Some sites had better fish than macroinvertebrate scores, and others vice versa. Big Flat Creek below Loganville (AR-13) clearly emerged as the most impaired site due primarily to ammonia toxicity. Habitat and biological degradation at other sites was attributable to sedimentation.

Channel Conditions

Similar to most Piedmont river systems, the primary cause of degraded stream conditions in the Alcovy is sediment. The river and its tributaries are already severely impacted by sediment that originates both from the channel itself and from land disturbing activities in the watershed.

Following the era of intense row-crop agriculture, streams became choked with sediment and unstable channels began to erode, leaving exposed banks and significant sediment deposits in downstream reaches. Stream channels in the Alcovy continue to erode today. Erosion is most pronounced in streams draining urban areas and in those reaches that were previously channelized.

Sediment was the primary reason for degraded aquatic habitat conditions and the absence of sensitive macroinvertebrate and fish species at most Alcovy biological monitoring sites. Impairment was due mostly to large and widespread deposits of sediment in the observed study channel reaches, and less from riparian vegetation degradation. Bank stability scored low at the smaller Alcovy sites, indicating that bank sediments in these reaches could contribute to downstream sediment loadings. The exception was the most downstream site at Newton Factory Mill Road just upstream of Lake Jackson. The stream gradient is higher in this reach of the river, thus creating conditions favorable for aquatic life (rock outcrops and riffles). Sediment deposition also decreases longitudinal stream gradient and creates conditions favorable for beaver, which in turn affects stream hydrology. Stream reaches such as Cornish Creek at Lower Jersey Road and Beaverdam Creek at Stock Gap Road that were once channelized are inhabited by beaver today. Beaver dams create sluggish flow conditions uncharacteristic of Piedmont streams.

This assessment of channel conditions shows that historical land use practices have had a significant influence on stream geomorphology, which, in turn, significantly affects water quality and aquatic habitat. Urbanization can contribute additional sediment loadings to streams and accelerate channel erosion through increased runoff from paved surfaces. These combined effects further degrade channel and water quality conditions. The primary control mechanisms to offset these effects are improved stormwater management for downstream channel and water quality protection and minimization of sediment delivery to streams.

Evaluation of Watershed Protection Measures

This section describes the procedures used to evaluate various watershed protection measures. Modeling scenarios were developed to test individual water quality improvement policies. The purpose of modeling these scenarios individually is to provide the TAC and elected officials with the best information possible on the potential effect selected policies and land management alternatives may have on selected water quality parameters in the Alcovy Basin. This will facilitate a more informed level of decision making than is generally available to local governments faced with potential water quality problems.

Model scenarios are summarized in Table A-2. The fundamental model input for each of the future scenarios will be the version of the projected land cover for the year 2020. This coverage was generated using county comprehensive management plans and was altered according to changes agreed upon by the TAC and planners in each county. This land cover remained

essentially constant for each trial run to determine the effect of potential policy changes. In some cases, policies are tested by making slight changes to this land cover. In other cases, a pollution reduction factor is applied to individual land cover types. Details of each model scenario, including the assumptions that were made for each, are given in the *Alcovy River Watershed Assessment*.

There are also a number of policies which do not readily lend themselves to analysis through modeling but which nevertheless could be very important for protecting water quality. For example, the explicit effect of a public education program cannot be realistically modeled. Furthermore, practical constraints limit the number of alternative scenarios that we can examine using BASINS. Therefore, scenarios were selected that will yield the most useful information. However, the local jurisdictions and the Northeast Georgia RDC will have the capacity for an unlimited number of additional model runs after the project is completed, if more information is needed.

For more information, go to the Northeast Georgia RDC website at: www.negrdc.org or to the Team Alcovy website at: www.teamalcovy.com .

Table A-2. Model Scenario Descriptions

Model Scenario	Model Objective	Area Modeled	Land Cover	Specific Data Needs/Input
1	To determine current water quality under present land use ordinances	Alcovy Watershed	Existing (1999)	Satellite imagery of existing land cover
2	To determine default future water quality under existing land use ordinances + Part V Criteria, as written	Alcovy Watershed	Future (2020)	Future land use cover for each county
3a	To determine future water quality with conservation subdivisions	Alcovy Watershed	Future (2020)	Percent impervious surface reductions for conservation subdivisions
3b	To determine future water quality with riparian buffer ordinances	Alcovy Watershed	Future (2020)	Pollutant removal efficiencies for rip. buffers
3c	To determine future water quality with impervious surface restrictions	Alcovy Watershed	Future (2020)	Pollutant removal efficiencies for imp. surfs
3d	To determine future water quality with stormwater infiltration	Alcovy Watershed	Future (2020)	Pollutant removal efficiencies for infiltration
3e	To determine future water quality with improved enforcement of erosion and sedimentation laws	Alcovy Watershed	Future (2020)	# ac/yr under construction Pollutant loading reductions
3f	To determine future water quality using some combination of 3a-3e	Alcovy Watershed	Future (2020)	Same as selected scenarios
3g	To determine future water quality using some combination of 3a-3e	Alcovy Watershed	Future (2020)	Same as selected scenarios
4	To determine water quality of alternative 2020 futures: planned (default future for Newton + new for Walton) vs sprawl (default future for Walton + new for Newton)	Cornish Creek Sub-basin	Alternative 2020 Futures	

Constituents selected for Alcovy River modeling include flow, sediment, phosphorus, fecal coliform and metals. Data were collected that allowed for model calibration for each parameter, with the exception of metals. Results were in the form of pollutant loadings at the downstream end of each of the watershed sub-basins. Results are compared to loadings under the present and the “default” future in which only the state-required minimum policies are implemented.

As with any modeling approach, there are limitations and assumptions. These are described in further detail in the *Alcovy River Waterhsed Assessment*. The outcome of the scenario modeling should be viewed as just one factor in selecting policies that are best for the future of the Alcovy River Watershed. Other factors such as cost, public opinion, and other benefits not measurable by BASINS (such as the important habitat benefits of riparian buffers) should be considered as well.

Model Results

BASINS was applied to the Alcovy River watershed, using site-specific data on features such as climate, land cover and hydrology. These data were supplemented with water quality and flow data collected at multiple locations throughout the watershed. The watershed model was calibrated for current conditions using the water quality and flow data. The calibrated model was then used to assess the water quality impacts of various future land use scenarios within the Alcovy basin.

Under projected future (2020) land use conditions with no additional controls, sediment loads are projected to increase by 137% and 152% over current loads above Jackson Lake and near the Walton/Newton line, respectively. The increase in loads is attributed to the projected increase in development. Similar trends were observed for other model parameters (Total Phosphorus and fecal coliform). The execution of each individual implementation option was minimally effective in reducing future pollutant loads. Model results indicated that an improved stormwater management ordinance (designed for downstream channel and water quality protection) offered the highest degree of water quality protection. Such measures would reduce total suspended solids in surface water by 28%, Total Phosphorus by 28%, and fecal coliform by 46%. This reduction was greater than the combined reduction from all other modeled policy tools. In each scenario, pollutant loads are expected to increase significantly above current loading, even with the implementation of Best Management Practices (BMPs).

Developing a Watershed Protection Plan

The Alcovy Watershed Protection and Implementation Plan was developed to provide a framework for implementation of water quality protection policies, incentive tools, and other protection measures. Some areas of the Alcovy watershed have grown rapidly in recent years and others are projected to continue to develop at an accelerated pace. The

assessment portion of the Alcovy Watershed Protection Project predicted that the major threat to water quality over the course of the next 20 years would be urbanization. Accordingly, most recommendations presented in the *Alcovy River Watershed Protection Plan* were concerned with managing growth to minimize its impact on water quality. The purpose was not to discourage development, but to ensure that the development that does occur minimizes any adverse affects to water supplies and stream health.

Most of the plan recommendations were in the form of ordinances or policies to be implemented by the local governments within the watershed (non-structural). Other recommendations included watershed protection measures that may be achieved on an administrative level or through partnership or cooperative agreements (includes both structural and non-structural). Many incentive-based and other implementation tools were recommended for all counties. However, not all policy tools were recommended for all jurisdictions. Because problems were both complex and variable across the region, it was determined that a cookie-cutter approach that emphasizes a few simple solutions would not meet this goal. Recommendations were tailored to each county jurisdiction, with plans to incorporate specific recommendations for cities as part of the long-term implementation of the plan.

Local governments have the choice of implementing a suite of policy tools that meet water quality targets and that are suited to their individual needs and requirements. Some local governments already passed ordinances similar to those recommended in the Plan, while others did not. Other implementation tools were less practical in some areas than others. Recommendations were prioritized by county according to those that were considered vital to the Plan, and those that fell into a general recommendations category. Some governments may choose to focus on a few of the most effective policies (i.e. the stormwater management ordinance); others may want to implement a range of solutions. Implementation options are discussed in further detail

Features of a the Alcovy Watershed Protection Plan

The Alcovy Watershed Protection Plan was based on implementing a combination of solutions. Part of the long-term execution of the plan includes developing a strategy to incorporate specific recommendations for cities within the Alcovy watershed.

Policy Tools

- Improved Stormwater Management Ordinance
- Riparian Buffer Ordinance
- Conservation Subdivision Ordinance
- Transferable Development Rights (TDRs)

Incentive-based Tools

- Water Conservation Programs
- Land Acquisition Programs
- Alternative Wastewater Management

Other Implementation Tools

- Conservation Planning
- Regional Planning and Cooperation
- Continuous Watershed Monitoring and Model Calibration
- Stream Restoration and Urban Retrofit
- Incentives for Agricultural Best Management Practices
- Improved Enforcement of Existing Erosion and Sediment Control Ordinances
- Community Education and Partnering

Recommendations for Ongoing Public Involvement Efforts

The Alcovy River is a valuable resource for drinking water, recreation, and for support of its unique ecology. Citizens have repeatedly expressed interest at community presentations and public meetings, and within individual discussions in preserving its unique qualities. The Alcovy River Watershed Protection Project was only the first step in a long-term process of creating a communal legacy of water quality protection. The optimal time to cultivate this interest is now, before the projected rapid growth. Considerable time and effort has been invested in providing stakeholders with information necessary to make informed decisions concerning water quality protection.

These community stakeholders can become key leaders for influencing public opinion, and are a tremendous resource for creating a springboard for long-term citizen action.

Often, people are simply unaware of the steps they can take to influence policy decisions and other initiatives to protect water quality. This section provides avenues for sustained public involvement in the management of the Alcovy River and offers several productive outlets for citizen energy and interest. An increasing number of state and local governments have recognized that trained and motivated citizens can provide valuable input to decisions regarding watershed protection. The "Team Alcovy" public involvement process has established a link with stakeholders within the impacted communities, and ongoing public outreach efforts would reinforce the successful implementation of the Watershed Plan and long-term protection of the Alcovy. Mutually-beneficial partnerships could be maintained with groups already exposed to the project and that are

responding to the watershed protection message. Below are some recommendations for continued public involvement in the Alcovy River Watershed Protection.

Alcovy Watershed Council. Members of the Technical Advisory Committee (TAC) and other stakeholders involved in the Alcovy project have expressed a desire for the establishment of a permanent Alcovy Watershed Council. The primary mission of the Council would be to gauge the success of the implementation of the Watershed Protection Plan. Regularly held meetings would provide a forum for regional discussions regarding policy changes, ordinance enforcement, and other local implementation efforts. Council members should include, if possible, representatives from all 15 city and county jurisdictions within the watershed. Each county may want to consider appointing a watershed coordinator to assume this role. Other potential council members could include former TAC members, elected officials, City and County Planning and Code Enforcement representatives, Public Works and Water and Sewer Authority officials, state Environmental Protection Division representatives, Soil and Water Conservation Commission (SWCC) and Natural Resources Conservation Service (NRCS) staff, water resource professionals and representatives from interested community groups.

The Alcovy Watershed Council should take advantage of the successful partnering effort begun with the Alcovy Watershed Protection Project between regulatory agencies, local officials and community groups. Such a partnership ensures the continuation of regional cooperation for effective growth management and water quality protection. The continued data collection and model calibration is paramount to the accuracy of future watershed assessments and the success of planning efforts. Thus, the Council may also act as a steering committee to direct future water quality monitoring and data collection and to coordinate with the Northeast Georgia Regional Development Center for model development.

The Council should continue the dialogue between jurisdictions and should encourage upstream and downstream neighbors to work together to address common watershed issues. Formation of this group would harness the energy and creative ideas of a broad spectrum of interested parties. The council should provide quarterly or bi-annual progress reports to the elected officials and the public on watershed plan implementation. There are many examples around the country as well as in Georgia of successful watershed groups working to protect water resources on a basin-wide scale.

Community Watershed Groups. Natural partners to the Watershed Council are local Community Watershed Groups. These groups should be citizen-based with an emphasis on coordinating grassroots efforts for protecting water quality. With a goal of helping residents "get their feet wet" in the Alcovy, these groups could work with existing community programs in their area, such as Adopt-a-Stream, and facilitating the formation of others. These community groups would be a valuable resource to the Watershed Council and local officials in extending community outreach and education efforts. They would also provide a forum for local discussions, and report to the Watershed Council on issues of importance to the community, ensuring that the public remains involved. Oxford College is a possible vehicle for organizing monitoring efforts in Newton County. The Newton Smart Growth is an organization interested in efficient development planning.

Citizen Soil Watch Groups. The Upper Chattahoochee River Keeper has developed a Citizen Soil Watch program. Several similar groups are active in and around the Atlanta area. The goal of the program is to educate citizens about proper erosion and sediment control practices and who to contact when there is a problem. Training courses are given to provide citizens with the tools necessary to properly identify erosion and sediment control failures. A scorecard is used to rate various practices, and a model letter has been developed for reporting failures to local code enforcement officials. The limitations of such an assessment must be recognized. All assessments are conducted from public right-of-ways to avoid conflicts of public access to the property, and therefore are not as complete as normal routine inspections. However, the overall goal is to identify gross, obvious problems that have a high probability of adversely impacting downstream waterbodies.

The most successful citizen soil watch groups are those that work cooperatively with local governments. It is recommended that all citizen complaints be funneled through a trained representative of the soil watch group. This representative would then be responsible for filtering out unwarranted complaints to avoid the potential problem of overburdening enforcement officials with a flurry of phone calls and letters.

Adopt-a-Stream. Giving residents an opportunity to "get their feet wet" in neighborhood streams often creates the greatest "buy-in" to county-wide protection measures. The Georgia Department of Natural Resources Environmental Protection Division Adopt-a-Stream program trains citizen volunteers to collect and analyze water quality samples, conduct biological assessments, and document stream and watershed conditions. Adopt-a-Stream groups also conduct visual surveys, improve stream habitat, and conduct stream cleanups. Both Newton and Walton County have Adopt-a-Stream programs; however, membership has declined in recent years. Local governments can offer support to these groups in the form of increased publicity (water bill stuffers, local access television, newsletters, etc.) or through sponsorship of training classes (providing speakers, materials, meeting space, etc.).

Educational Curriculum. Educating future generations of citizens and water consumers is a valuable way to ensure long-term change in behaviors impacting the Alcovy River. Local governments can create an attachment to issues specific to their community by encouraging educators to include them in classroom assignments. *The Water Source Book*, designed for grades K-12, is a tremendous resource for introducing water resources issues into classrooms, as is *Project Wet*. Developed with teachers, water industry professionals, and others, both of these curricula have been approved by the State of Georgia for inclusion in classroom lesson plans. They each offer hands-on activities for students, guidance materials for teachers, and a matrix for identifying which elements address specific teaching goals. Water resources issues can be used in science, art, language, social studies, mathematics, and other disciplines to illustrate basic principles, while also conveying the water resource management message. With little effort, local governments could personalize the curriculum to include information specific to the Alcovy River and its challenges.

Partnerships. Reaching out to interested stakeholders within the watershed creates opportunities for successful partnerships. During the course of the Alcovy Watershed Protection Project, hundreds of residents were accessed through community presentations made at local civic and professional association meetings. Local governments can partner with these groups to sustain the open lines of communication established at these presentations. Requesting regular placement (yearly, quarterly) on meeting agendas to offer updates, provide educational information, and receive input would be a first step toward assisting key opinion leaders within the community in making informed decisions. These opinion leaders also often contribute to community understanding of issues.

LESSONS LEARNED

Political will across jurisdictions is fundamental to the initiation and continuation of regional cooperation for watershed assessment and protection. Local governments wishing to cultivate such cooperation can benefit from having the local Regional Development Center act as an “impartial clearinghouse” for coordination between cities and counties. This approach helped to successfully foster a cooperative spirit throughout the Alcovy Watershed Protection Project.

While the assessment and plan development represented a significant financial investment, it is only a first step for long-term protection. Implementation of the watershed protection plan will require a long-term commitment from each of the cities and counties in the Alcovy River watershed. The benefits of regional cooperation that were realized in the assessment and planning phases can also be realized in future implementation. For example, there is a cost-savings long-term sampling and model calibration if it is performed regionally rather than individually by each jurisdiction.

Full implementation of the Watershed Protection Plan will provide a range of other benefits for the residents of the Alcovy Basin. It is far more effective and economically efficient to prevent aquatic degradation through good planning and enforcement than it is to restore degraded streams and retrofit stormwater controls once development has occurred. Proper planning and regulation of development will provide for a healthy local economy, protect natural resources and ensure a high quality of life for future residents of the Alcovy watershed.

APPENDIX B

DESCRIPTION OF COMMONLY-CONSIDERED WATER QUALITY CONSTITUENTS

Dissolved Oxygen

Fish and other aquatic animals depend on dissolved oxygen (the oxygen present in water) to live. The amount of dissolved oxygen in streams is dependent on the water temperature, the quantity of sediment in the stream, the amount of oxygen taken out of the system by respiring and decaying organisms, and the amount of oxygen put back into the system by photosynthesizing plants, stream flow, and aeration. Dissolved oxygen is measured in milligrams per liter (mg/l) or parts per million (ppm). The temperature of stream water influences the amount of dissolved oxygen present; less oxygen dissolves in warm water than cold water. For this reason, there is cause for concern for streams with warm water. Trout need DO levels in excess of 8mg/liter, striped bass prefer DO levels above 5 mg/l, and most warmwater fish need DO in excess of 2 mg/l.

Biochemical Oxygen Demand (BOD)/Chemical Oxygen Demand (COD)

Natural organic detritus and organic waste from waste water treatment plants, failing septic systems, and agricultural and urban runoff, acts as a food source for water-bourn bacteria. Bacteria decompose these organic materials using dissolved oxygen, thus reducing the DO present for fish. Biochemical oxygen demand (BOD) is a measure of the amount of oxygen that bacteria will consume while decomposing organic matter under aerobic conditions. Biochemical oxygen demand is determined by incubating a sealed sample of water for five days and measuring the loss of oxygen from the beginning to the end of the test. Samples often must be diluted prior to incubation or the bacteria will deplete all of the oxygen in the bottle before the test is complete.

The main focus of wastewater treatment plants is to reduce the BOD in the effluent discharged to natural waters. Wastewater treatment plants are designed to function as bacteria farms, where bacteria are fed oxygen and organic waste. The excess bacteria grown in the system are removed as sludge, and this “solid” waste is then disposed of on land.

Chemical oxygen demand (COD) does not differentiate between biologically available and inert organic matter, and it is a measure of the total quantity of oxygen requried to oxidize all organic material into carbon dioxide and water. COD values are always greater than BOD values, but COD measurements can be made in a few hours while BOD measurements take five days.

If effluent with high BOD levels is discharged into a stream or river, it will accelerate bacterial growth in the river and consume the oxygen levels in the river. The oxygen may diminish to levels that are lethal for most fish and many aquatic insects. As the river reaerates due to atmospheric mixing and as algal photosynthesis adds oxygen to the water, the oxygen levels will slowly increase downstream. The drop and rise in DO levels downstream from a source of BOD is called the *DO sag curve*.

pH/Acidity/Alkalinity

pH is a measure of the amount of free hydrogen ions in water. Specifically, pH is the negative logarithm of the molar concentration of hydrogen ions.
$pH = -\log[H^+]$

for example,	at pH 2,	$[H^+] = 10^{-2}$ or .01
	at pH 10	$[H^+] = 10^{-10}$ or .0000000001
	at pH 4	$[H^+] = 10^{-4}$ or .0001

Because pH is measured on a logarithmic scale, an increase of one unit indicates an increase of ten times the amount of hydrogen ions. A pH of 7 is considered to be neutral. Acidity increases as pH values decrease, and alkalinity increases as pH values increase. Most natural waters are buffered by a carbon-dioxide-bicarbonate system, since the carbon dioxide in the atmosphere serves as a source of carbonic acid.

$$H_2CO_2 \dashrightarrow HCO_3 + H^+ \qquad pK \sim 7.5$$

This reaction tends to keep pH of most waters around 7 - 7.5, unless large amounts of acid or base are added to the water. Most streams draining coniferous woodlands tend to be slightly acidic (6.8 to 6.5) due to organic acids produced by the decaying of organic matter. Natural waters in the Piedmont of Georgia also receive acidity from the soils. In waters with high algal concentrations, pH varies diurnally, reaching values as high as 10 during the day when algae are using carbon dioxide in photosynthesis. pH drops during the night when the algae respire and produce carbon dioxide.

The pH of water affects the solubility of many toxic and nutritive chemicals; therefore, the availability of these substances to aquatic organisms is affected. As acidity increases, most metals become more water soluble and more toxic. Toxicity of cyanides and sulfides also increases with a decrease in pH (increase in acidity). Ammonia, however, becomes more toxic with only a slight increase in pH.

Alkalinity is the capacity to neutralize acids, and the alkalinity of natural water is derived

principally from the salts of weak acids. Hydroxide, carbonates, and bicarbonates are the dominant source of natural alkalinity. Reactions of carbon dioxide with calcium or

magnesium carbonate in the soil create considerable amounts of bicarbonates in the soil. Organic acids such as humic acid also form salts that increase alkalinity. Alkalinity itself has little public health significance, although highly alkaline waters are unpalatable and can cause gastrointestinal discomfort.

Nutrients

Nutrients such as phosphorous and nitrogen are essential for the growth of algae and other plants. Aquatic life is dependent upon these photosynthesizers, which usually occur in low levels in surface water. Excessive concentrations of nutrients, however, can overstimulate aquatic plant and algae growth. Bacterial respiration and organic decomposition can use up dissolved oxygen, depriving fish and invertebrates of available oxygen in the water (*eutrophication*).

Fertilizers, failing septic systems, waste water treatment plant discharges, and wastes from pets and farm animals are typical sources of excess nutrients in surface waters. In aquatic ecosystems, because phosphorous is available in the lowest amount, it is usually the limiting nutrient for plant growth. This means that excessive amounts of phosphorous in a system can lead to an abundant supply of vegetation and cause low DO. The forms of nitrogen found in surface water are nitrate, nitrite, and ammonia. Ammonia is usually rapidly converted to nitrate in aerobic waters, as is true in soils (nitrate is a stable form of nitrogen, while ammonia is unstable). Ammonia is associated with municipal treatment discharges, and the stressing effects of ammonia on aquatic organisms, increase at low dissolved oxygen levels and at increased pH. Increased nitrogen levels adversely affect cold-water fish more than they do warm water fish. Nitrogen concentrations of 0.5 mg/liter are toxic to rainbow trout. Nitrogen is also a concern in drinking water because an increased level of nitrate has been linked with blue-baby syndrome in infants. In 1986, EPA established a 10 mg/liter concentration of nitrate as a standard for drinking water.

Limnologists and stream ecologists have broadly categorized the productivity of lakes and streams into three classes: *oligatrophic, mesotrophic, and eutrophic*. An *oligatrophic* water has very low inputs of nutrients and carbon, and so primary biological productivity (plant growth) is low. Water tends to be very clear. Most mountain streams and lakes in pristine areas tend to be oligatrophic. A *mesotrophic* water has moderate amounts of nutrients and carbon. Aquatic life tends to be very diverse in mesotrophic waters. A *eutrophic* water is highly productive because of high amounts of nutrients and carbon. Eutrophic waters tend to be unstable in their chemistry and biology, and as a result, species richness and diversity tends to be low even though biomass is quite high. Eutrophication is usually man-induced process where elevated nutrient levels over stimulate biological production.

Conductance or Electrical Conductivity (EC) and Dissolved Solids

Conductivity is the ability of a substance to conduct electricity. The conductivity of water is a more-or-less linear function of the concentration of dissolved ions. Conductivity itself is not a human or aquatic health concern, but because it is easily measured, it can serve as an indicator of other water quality problems. If the conductivity of a stream suddenly increases, it indicates that there is a source of dissolved ions in the vicinity. Therefore, conductivity measurements can be used as a quick way to locate potential water quality problems. Conductivity is measured in terms of conductivity per unit length, and meters typically use the units microsiemens/cm.

All natural waters contain some dissolved solids due to the dissolution and weathering of rock and soil. Dissolved solids are determined by evaporating a known volume of water and weighing the residue. Some but not the entire dissolved solids act as conductors and contribute to conductance. Waters with high total dissolved solids (TDS) are unpalatable and potentially unhealthy. Water treatment plants use flocculants to aggregate suspended and dissolved solids into particles large enough to settle out of the water column in settling tanks. A flocculent is a chemical that uses double-layer kinetics to attract charged particles.

Metals, Pesticides and Herbicides, Organics

Metals, petroleum products, and organic contaminants, including solvents, electrical insulators, lubricants, herbicides, fungicides, and pesticides, can accumulate in aquatic environments and cause toxic effects on aquatic life and increase health risks of drinking water. These chemicals are at very low concentrations in the natural environment, and they are typically introduced to surface waters as waste from human activities. Some of the metals of concern for human and aquatic health are cadmium, lead, copper, mercury, selenium, and chromium. Cadmium is widely used in industry and is often found in solution in industrial waste discharges. Cadmium replaces zinc in the body, and long-term consumption of cadmium may lead to bodily disorders. Cadmium is toxic to both humans and fish and seems to be a cumulative toxicant. Small salmon fry have been killed from concentrations of 0.03 mg/liter

Lead sources are batteries, gasoline, paints, caulking, rubber, and plastics. Lead can cause a variety of neurological disorders. In children, it inhibits brain cell development. Lead also prevents the uptake of iron, so people ingesting lead often exhibit symptoms of anemia including pale skin, fatigue, irritability, and mile headaches.

Metal plating, electrical equipment, pesticides, paint additives, and wood preservatives are sources of copper. Copper is also toxic to juvenile fish. Other toxicants that are associated with industrial effluent are mercury and silver. Mercury and silver affect fish

in ways similar to cadmium, copper, lead and zinc. When fish are exposed to either of these at certain concentrations, gill tissues are damaged and death by asphyxiation can occur.

Pesticides and herbicides are found in streams and rivers draining agricultural and residential areas, usually during periods of extended wet weather or intense precipitation when overland flow is most likely. These substances are toxic to many aquatic organisms and they may act as mutagens for human beings. Since water treatment plants are not designed to remove these substances, it is important to prevent their introduction to drinking water supplies.

There are a wide variety of organic chemicals, including chlorinated hydrocarbons, that are used as solvents, cleaners, lubricants, insulators, and fuels in many industries. Many of these chemicals are believed to be cancer-causing agents. Since these are organic chemicals, most of them are biologically active to some degree. This means that bacteria in the environment often degrade these substances into byproducts. Unfortunately, some of these byproducts are more toxic than the original substance.

The EPA regulates concentrations of literally hundreds of these chemicals in drinking water and groundwater. These chemicals are often found in association with each other, and the inter-actions of these chemicals as mutagens are poorly understood. Because they are suspected cancer-causing agents, regulatory levels for many of these chemicals are in the parts per billion range, which means that analytical techniques for these chemicals are rigorous, time-consuming, and expensive. False positive measurements for these chemicals are quite common.

Sediment and Substrate

Sediment enters streams via upland soil erosion, bank erosion, and land sliding. Sediment is a natural component of streams, but excessive sediment can be carried into streams and rivers from erosion of unstable streambanks, construction sites, agricultural activities, and urban runoff. Sediment moves downstream in a river in two forms: *suspended load* and *bed load*. *Suspended load* includes the particles in suspension in the water column. The red-brown color of Georgia Piedmont streams is due to clay and colloid particles in suspension. *Bed load* refers to the sediment pushed along the bottom of the channel. Coarser substrate such as sand and gravel tends to move as bed load, not suspended load.

Sediment is usually measured as a concentration of total suspended solids (TSS), which is the dry weight after filtering a water sample, expressed in mg per liter. To determine a suspended sediment load (mass/time), the TSS concentration must be multiplied by the flow rate (volume/time). *Turbidity* is another indicator of the amount of material

suspended in water; it measures the amount of light that is scattered or absorbed. Suspended silt and clay, organic matter, and plankton can contribute to turbidity. Photoelectric turbidimeters

measure turbidity in nephelometric turbidity units (NTUs). Turbidity units are supposed to correspond to TSS concentrations, but this correlation is only approximate.

Turbidity in a stream will fluctuate before, during and after stormflow. Georgia Rules and Regulations for Water Quality Control, Chapter 391-3-6 (February 2000…need to check latest), give general criteria for all waters, which include narrative standards for turbidity:

> **"All waters shall be free from material related to municipal, industrial or other discharges which produce turbidity, color, odor or other objectionable conditions which interfere with legitimate water uses," (Paragraph 391-3-6-.03(5)(c).**
>
> **"All waters shall be free from turbidity which results in a substantial visual contrast in a water body due to a man-make activity. The upstream appearance of a body of water shall be as observed at a point immediately upstream of a turbidity-causing man-made activity. That upstream appearance shall be compared to a point which is located sufficiently downstream from the activity so as to provide an appropriate mixing zone. For land disturbing activities, proper design, installation, and maintenance of best management practices and compliance with issued permits shall constitute compliance with [this] Paragraph 391-3-6-.03(5)(d)."**

Furthermore, the new general NPDES stormwater permit for constructions sites requires that the difference in turbidity not exceed 25 NTU downstream from a construction site compared to upstream. If this criterion is exceeded AND if Best Management Practices (BMPs) are not properly designed, installed or maintained, then the permittee is subject to fines and third party lawsuits (Appendix K).

Turbidities of 10 NTU or less represent very clear waters; 50 NTU is cloudy; and 100-500 or greater is very cloudy to muddy. Some fish species may become stressed at prolonged exposurses of 25 NTUs or greater. Furthermore, Barnes (1998) recommended that to maintain native fish populations in Georgia Piedmont rivers and streams, that random monthly values should never exceed 100 NTU; that no more than 5 percent of the samples should exceed 50 NTU; and no more than 20% should exceed 25 NTU.

Similarly, average TSS concentrations in the range of 25-80 mg/L represent moderate water quality. An average concentration of 25 mg/L has been suggested as an indicator of unimpaired stream water quality (Holbeck-Pelham and Rasmussen, 1997). Some states use 50 mg/L as a screening level for potential impairment to waterbodies.

Fine sediment deposited on the stream bed can fill gravel spaces, eliminating spawning habitat for some fish species and also eliminating habitat for many invertebrate species.. Turbidity and or TSS can reduce light penetration, decreasing algal growth, and low algal productivity can reduce the productivity of aquatic invertebrates, a food source of many

fish. High turbidity levels affect fish feeding and growth; the ability of salmonids to find and capture food is impaired at turbidities from 25 to 70 NTU. Gill function in some fish may also

be impaired after 5 to 10 days of exposure to a turbidity level of 25 NTU. Turbidities of less than 10 describe very clear waters. Waters with turbidity in excess of 50 are quite cloudy, and waters with turbidities exceeding 500 are downright muddy.

Large bed loads can also reduce or eliminate pool habitat essential to low-flow and summer survival of fish. Essentially, channels with high bed loads tend to feature shallower water and a larger wetted perimeter. Channel bed topography as well as the size distribution of sediments on the bottom of the channel (referred to as substrate) are vital factors for the productivity of many fish species. Pools provide resting areas for fish, protection from terrestrial and avian predators, and sometimes provide cooler water, which lowers metabolic needs. Areas of cool water in streams and lakes are called thermal refugia.

Temperature

Metabolic rate and the reproductive activities of aquatic life are controlled by water temperature. Metabolic activity increases with a rise in temperature, thus increasing a fish's demand for oxygen; however; an increase in stream temperature also causes a decrease in DO, limiting the amount of oxygen available to these aquatic organisms. With a limited amount of DO available, the fish in this system will become stressed. A rise in temperature can also provide conditions for the growth of disease-causing organisms.

Water temperature varies with season, elevation, geographic location, and climatic conditions and is influenced by stream flow, streamside vegetation, groundwater inputs, and water effluent from industrial activities. Water temperatures rise when streamside vegetation is removed. When entire forest canopies were removed, temperatures in Pacific Northwest streams increased up to 8^{o} C above the previous highest temperature. Water temperature also increases when warm water is discharged into streams from industries.

Woody Debris

Depending on the size and gradient of a channel, the amount and size of woody debris in the channel can have a dramatic effect on the habitat quality and productivity of a channel. Woody debris serves as a scour element, meaning that during high flows water is accelerated in a downward direction around the woody debris and scours out a hole around the bottom of the debris. This hole serves as a pool between storms. The wood itself provides cover, or hiding places, for the fish using the pool. When a stream is

surveyed via electroshocking methods, many of the fish are found in the pools below and around woody debris. In sandy-bottomed streams, wood serves as the best food source and growth platform for aquatic invertebrates. In Coastal Plain streams in Georgia, more than 60% of the

food source for fish comes from invertebrates grown on the woody debris. To protect the quality of habitat in a stream or river, it is necessary to maintain a forested riparian corridor from which large woody debris can fall into the channel.

Channel Morphology / Human Channel Manipulation

Channel morphology encompasses all aspects of a channel's shape, structure, habitat characteristics, and substrate and also the response of a channel to changes in physical inputs. Channel morphology is a function of climate, topography, geology, land use, riparian condition, sediment loading, and flows. Physical water quality considers all aspects of channel morphology, as illustrated above, but also considers temperature and direct human alteration of streams and rivers. A stream that has been placed in a culvert obviously retains few ecological functions.

Culverts and other fish passage barriers such as tide gates are physical alterations that can have large impacts on regional fish populations. A fish population within a given small stream is always in danger of extirpation due to habitat disturbance (a big flood, a chemical spill, a landslide, etc.). As long as this local population can interact with the metapopulation downstream, the habitat can be recolonized. If an impassable culvert prevents upstream migration, however, the total habitat area for a species is reduced. A fish can only swim so fast and so long, and therefore a long culvert with high velocity water prevents upstream migration.

Bacteria

Bacteria and viruses from human and animal wastes carried to streams can cause disease. Fecal coliform, found in the intestines of warm-blooded animals, is the bacteria for which many states' surface water quality standards are written. Fecal coliform bacteria do not cause disease but are used as an indicator of disease causing pathogens in the aquatic environment. The GA standard is 200 colonies per 100 ml of sample water, but the State of California Water Pollution Control Board recommends concentrations of less than 5 colonies per 100 ml of sample for shellfish culture. Typical sources of bacteria are sewage from septic system failure and stormwater overflows, poor pasture management and animal-keeping practices, pet waste, and urban runoff. High bacteria levels can limit the uses of water for swimming or contaminate drinking water in groundwater wells. The presence of excessive bacteria also may indicate other problems, such as low DO.

Indicator Species or Guilds

The physiology or life history of certain aquatic species makes them very good biological indicators of physical and chemical water quality. Essentially, some species are more sensitive to chemical or physical water quality impairment, and if these species are reduced in numbers or not present in a portion of their range, this often indicates a problem with water quality. Surveys of

the presence and abundance of aquatic species, therefore, can reveal locations of water quality problems.

If poor water quality conditions eliminate the more sensitive species from an ecosystem, then one would expect the species richness and diversity to decline. Species richness is the total number of species in a system, while diversity is typically defined as the ratio of the richness to the total number of individuals. Based on this concept, aquatic scientists have developed a series of metrics known as Indices of Biological Integrity (IBIs), which are statistical metrics accounting for species richness, species abundance, and diversity. IBIs can be calculated for invertebrate communities or fish communities. IBI scores have been shown to be negatively correlated with percent urbanization of a watershed. The more a watershed is developed, the lower the IBI score becomes. IBIs are relatively easy to measure, so overall water quality conditions can be mapped over entire landscapes using IBIs.

Overall Water Quality

The chemical, physical, and biological aspects of water quality are inter-related and most be considered together. For example, higher water temperature reduces the solubility of dissolved oxygen, and may cause a dissolved oxygen shortage that kills more sensitive fish species. The rotting fish carcasses may contribute to a bacterial bloom that makes some human swimmers or boaters ill.

Water quality is highly variable over time due to both natural and human factors. Water temperature, photosynthetic activity, and flows vary with season. Flows, and therefore suspended sediment, can vary daily with rainfall. Nutrient loads can vary with season (homeowners fertilizing in the spring), flow (runoff mechanisms affect pollutant wash-off), and human management (nitrogen is released after a clearcut). A comprehensive characterization of natural water quality therefore requires a large amount of data. Water quality data is expensive and time-consuming to acquire, however, so water quality managers usually deal with a large amount of uncertainty.

The Environmental Protection Agency (EPA) is the federal agency charged with regulating water quality in the United States. They have set standards for acceptable levels of many aquatic contaminants in drinking water. They have also set targets or guidelines for some water quality characteristics directed at aquatic ecosystem health,

fisheries concerns, and safety for human recreation. Table 1 summarizes some of the EPA guidelines for common water quality constituents.

Table B-1. Effects and Drinking Water Standards for Some Water Quality Characteristics

Water Quality Characteristic of Concern	Ecological or Health Effect	Standard	Notes
Dissolved Oxygen	High levels of dissolved oxygen are necessary for fish respiration.	5.0 mg/l average 4.0 mg/l minimum	GA water quality standards.
Temperature	Fish suffer metabolic stress at high temperatures.	90 ^{o}F maximum	GA water quality standards.
pH	pH affects the solubility of other water quality contaminants.	6.0 - 9.5	GA water quality standards.
Fecal coliform	Fecal coliforms do not pose a health threat but serve as an indicator for bacteria that can cause illness in humans and aquatic life.	200 col/100ml (May-Oct) 1000 col/100 ml (Nov - April) 4000 col/100 ml (anytime)	GA water quality standards.
Phosphorus	Macronutrient affects aquatic productivity and trophic state.	No effective standard in GA	Any existing standards are waterbody-specific
Total Nitrogen	Macronutrient affects aquatic productivity and trophic state.	4.0 mg/l	GA water quality standards.
Nitrate	Causes blue baby syndrome.	10 mg/l	Federal Drinking Water Std.
Metals: Arsenic Cadmium Chromium Copper Lead Mercury Silver	Heavy metals cause a variety of problems including interfering with vitamin uptake, neurological disorders, and disruption of renal function. These problems result from chronic and cumulative exposure.	mg/l 0.05 0.01 0.05 1.0 0.05 0.002 0.05	Federal Drinking Water Standards.
TDS	General indicator of ion concentrations. Affects taste.	500 mg/l	Federal Drinking Water Std.

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